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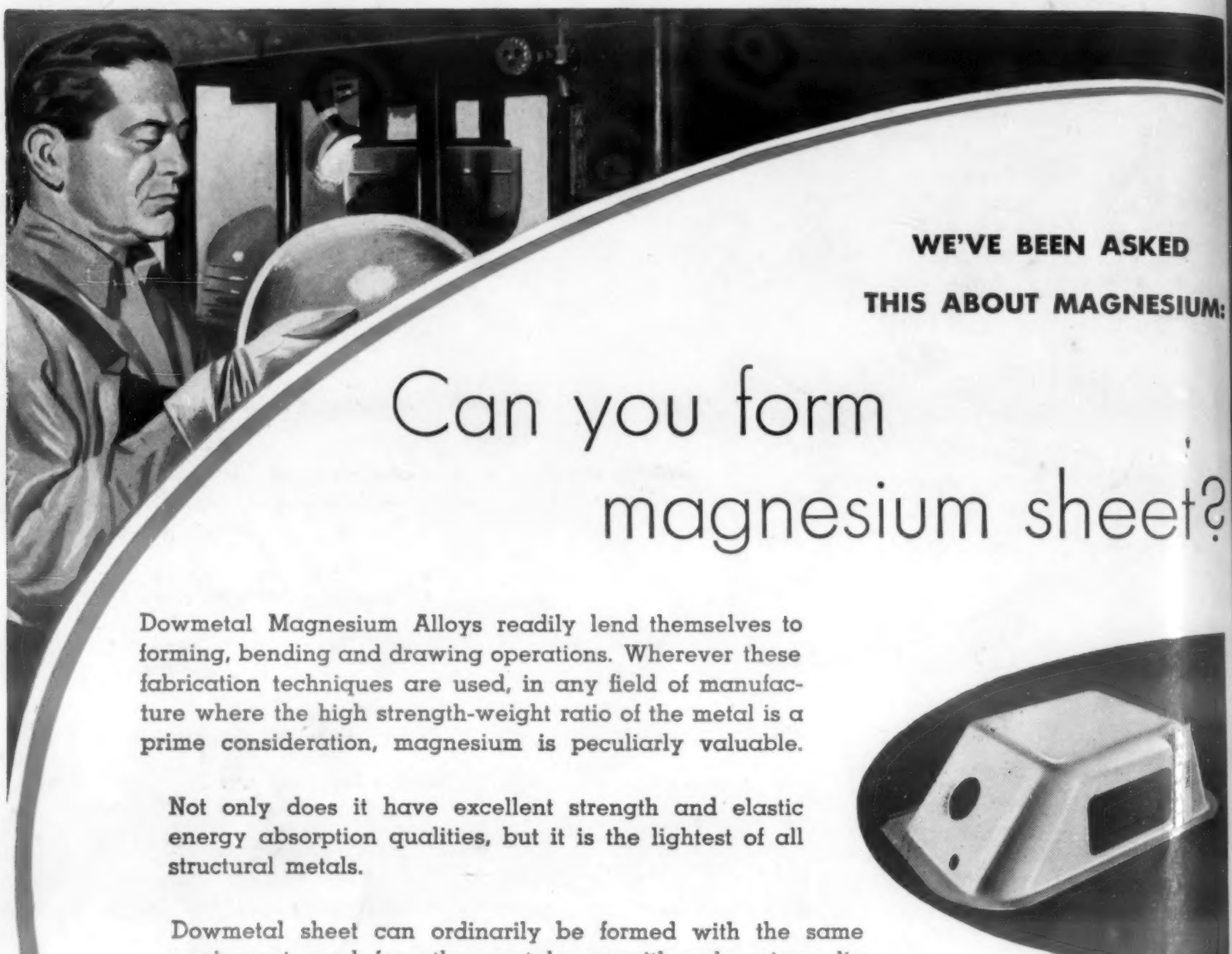
METALS and ALLOYS

The Engineering Magazine of the Metal Industries

July 1944



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METALS and ALLOYS

The Engineering Magazine of the Metal-Working Industries

VOLUME 20 • NUMBER 1 • JULY, 1944

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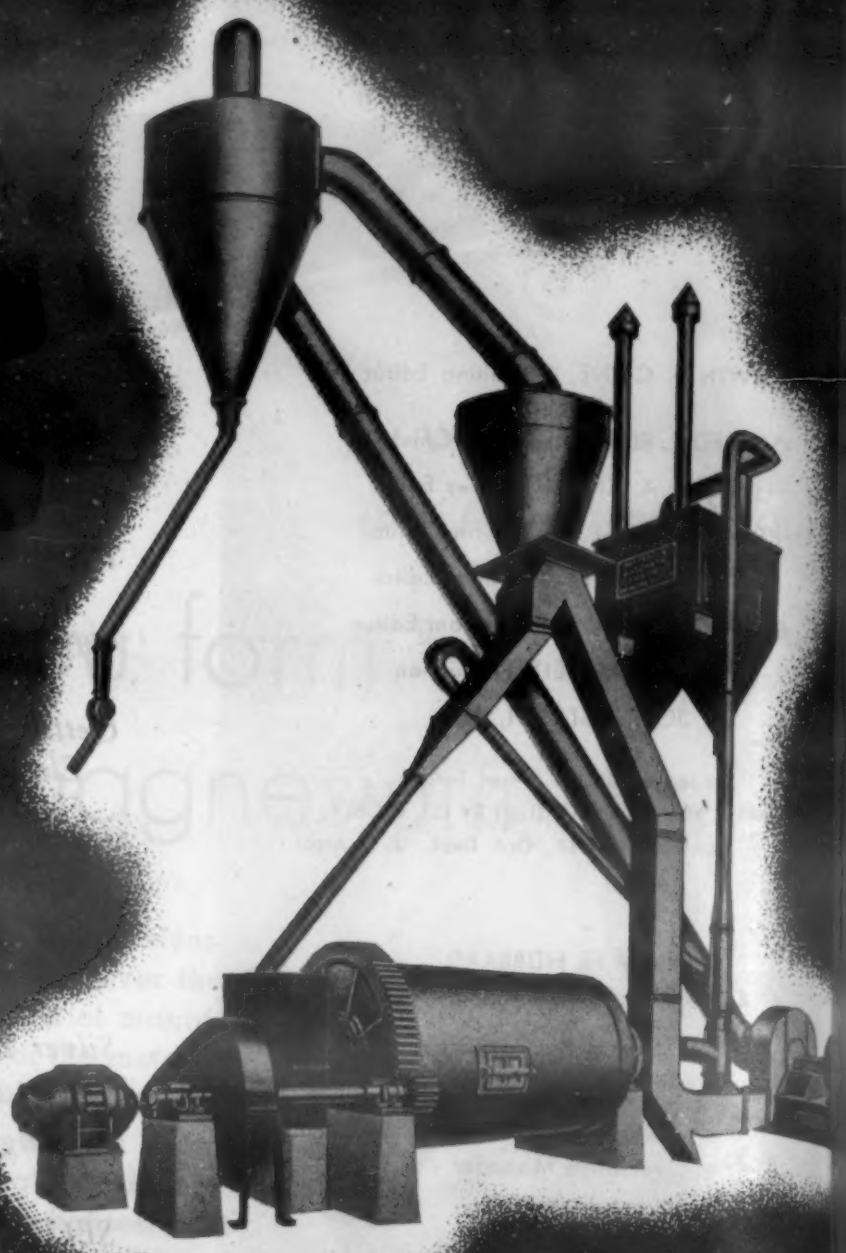
GUIDEPOST

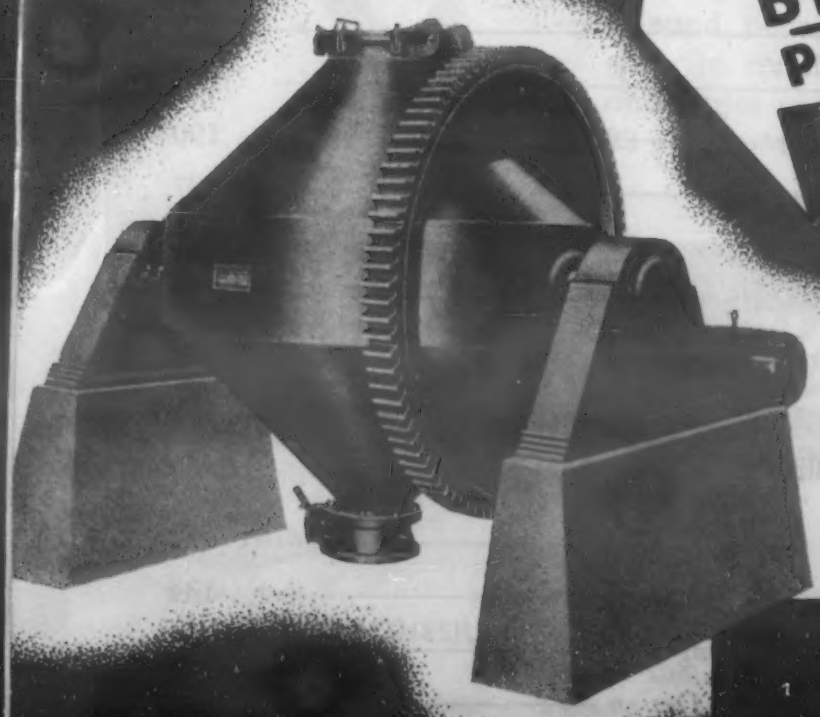
to Quality in

POWDER METALLURGY



THIS WAY TO
BETTER METAL
POWDER *Production*

THIS WAY TO
BETTER METAL
POWDER *Blending*



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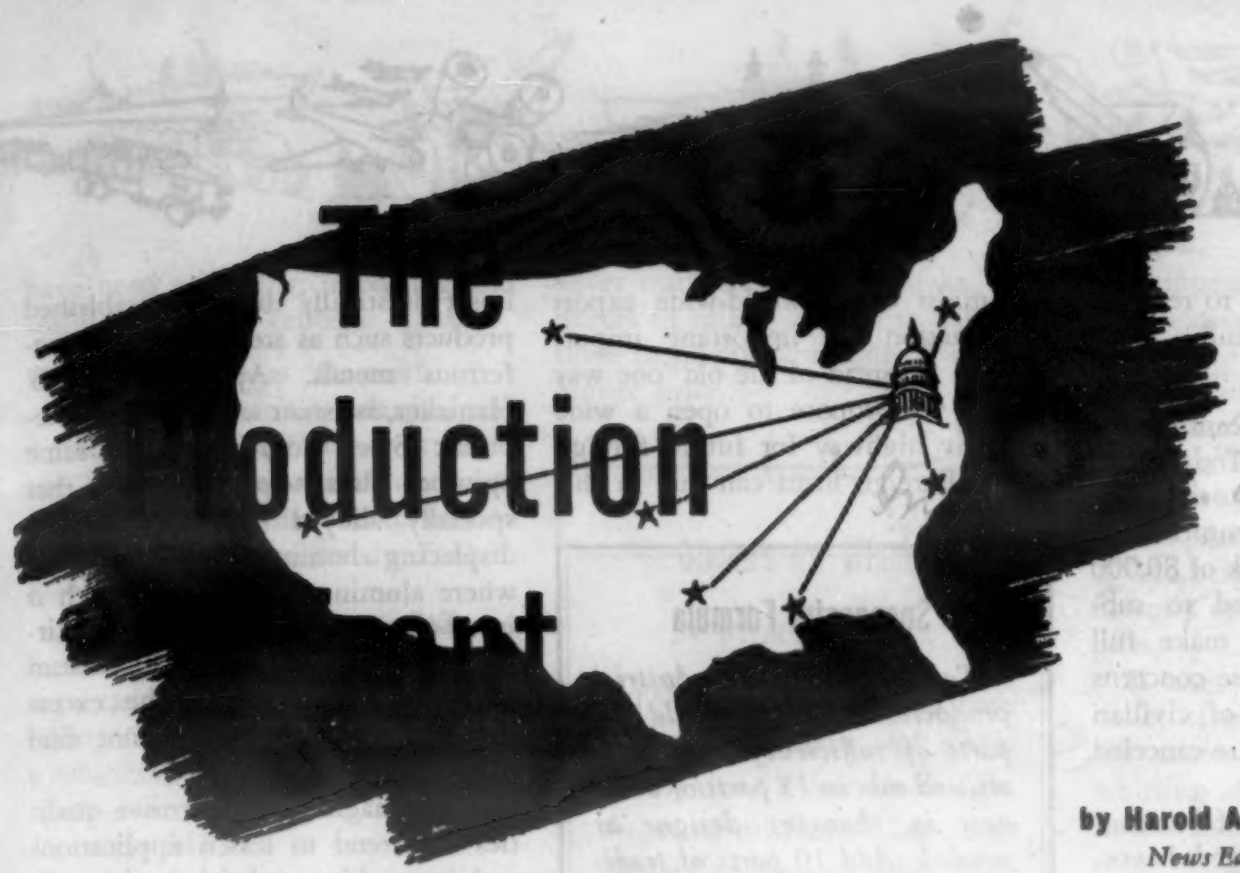


Production spurts on certain items. . . . Tanks make comeback after slipping in prestige. . . . More heavy artillery needed to blast through cities. . . . Rockets are No. 1 in priority. . . . When Germany falls we will convert up to 50% to peace. . . . Fifty-six household articles surveyed as to scarcity.

British industry, except for aircraft and shipbuilding, paced at 35% of year ago. . . . Reynolds suggests forming of a third big aluminum producer. . . . Another proposes we "chink in" civilian production. . . . Large manufacturer plans for heavy imports. . . . Steel man pooh poohs aluminum, plastics, etc. as serious steel rivals. . . . Movement grows to import metals to save our own.

Increased productivity in airframe industry "breath-taking". . . . Cartoon about your first article of clothing, reader. . . . Our weapons are now superior to the Germans'. . . . U. S. lead production will never again equal past records. . . . We saw the old "Olympia" near a modern battleship. . . . Predicted that rockets may supplant heavy artillery.

On With the War—But, Ditto, Peace!

by Harold A. Knight
News Editor

The most convincing indication that our war production has not yet been completed and that we cannot yet coast from here on in are the orders of recent months to concentrate on and speed up in certain items, such as heavy artillery and its ammunition; also tanks and rockets.

A manufacturer of rockets recently told us that this line of manufacture now has top priority on men and materials, but priorities undoubtedly stand high with items we have mentioned above, plus landing barges, electronic equipment and the old standard item, airplanes.

It is indeed almost breath-taking —the manner in which military strategy and lines of production shift. A year ago last March they told us solemnly at the Aberdeen Proving Grounds that the days of the tank in warfare were numbered, hinting that mobile anti-tank guns had made tanks obsolete.

It probably all came about near Tobruk in Africa. Rommel had played the "Come-on" game, enticing British tanks into hot pursuit. Presto! Out of camouflage emerged the new German 88 guns, and in a few short minutes they destroyed 75% of the British tanks.

But apparently the tank is making a comeback. Our gun turrets that revolve 360°; the gyroscopic stabilizers allowing for accurate shooting on the run; the effective Russian method of having infantry trail in the shadow of the tanks, etc. have again made tanks highly respected.

The need of overwhelming numbers of heavy artillery pieces is evident, now that we have set foot in France and may have to blast our way, city by city, as we blasted Cherbourg. We found on Italian beachheads, too, that for a time German guns were outranging ours.

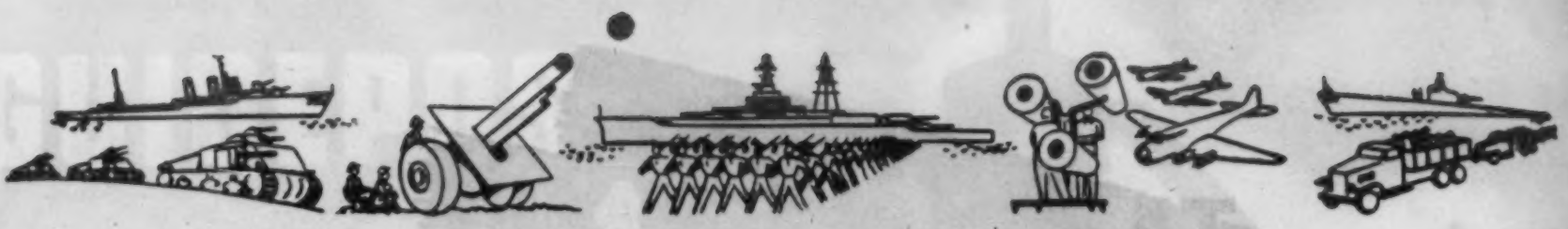
Down to Grass Roots in P-W Planning

With the successful invasion of France, rapid progress in Italy, fast-moving Russian campaigns and many victories over the Japanese, the time appears at hand to plan for the early post-war and at least semi-conversion to peace manufacture at once. Whereas a month ago Washington was guardedly mentioning a 35% conversion to peace when Germany is beaten, the brass hats have become bolder, now mentioning 40 to 50% of our plant capacity to peace goods.

A survey was conducted by WPB among 4500 nationally representative families. The demand for 56 household articles is shown in proportion to available supply. Percentage of satisfied demand varies from 98% for sewing thread to 5% for wash boilers and lawn mowers.

Articles available to meet only one-third the demand are radio tubes, window screening, electric heating pads, can openers, alarm clocks, carpet sweepers, extension cords, frying pans, double boilers, tea kettles, wash tubs and step-on garbage cans.

There are countless other shortages not mentioned in this survey, such as automobiles, refrigerators and ranges. Presumably these known



shortages will be a guide to resumption of civilian manufacture.

120,000 Firms to Reconvert

Donald M. Nelson recently said, bearing on this subject: "Today there are about 40,000 manufacturing concerns holding direct government war contracts, and the war work of 80,000 additional firms is limited to subcontract operations. To make full use of their resources, these concerns will need a big volume of civilian orders before war orders are canceled in bulk.

"However, cancellation of war contracts so far has not played havoc. Out of $210,000,000,000 in prime contracts from the Government since June, 1940, terminations up to April, 1944 have been only $22,000,000,000, with most of the canceled contracts swiftly replaced with new ones."

The danger of not launching quickly enough into peace conversion may be indicated by the experience of Britain. Today her industry is working at only 35% of the rate of a year ago, with the exception of airplane manufacture and shipbuilding, a prominent Britisher told us recently.

Post-war plans now being voiced are in several instances more definite than vague statements of a few months back. Thus, R. S. Reynolds, president, Reynolds Metals Co., makes a plea that government-owned magnesium and aluminum plants be leased to private industry after the war—say to Henry Ford—to make a third great producing company and help avoid danger of monopolistic price increases.

"Chink In" Theory of Peace Output

Suggesting a plan for the more immediate future, I. W. Wilson, vice president, Aluminum Co. of America, has proposed the "chink in" theory of reconversion to peace. When one war contract expires, manufacturers should be permitted to "chink in" production of civilian goods until the next war contract appears.

Westinghouse has already put into effect a post-war plan that should benefit the entire nation, at least if followed by others. It has formed in the midst of its world-wide export organization an important import branch. "Instead of the old 'one way street', we propose to open a wide two-way highway for future foreign trade. Foreign firms can buy in this country and pay for what they buy with their own local products," an official states.

Successful Formula

Take 30 parts of industrial production ingenuity, add 25 parts of sufficiency in materials, and mix in 15 parts of boldness in changing designs as needed. Add 10 parts of tradition and background in mechanical skills, stir in slowly 10 parts of the crusading spirit for a just cause, and add 10 parts of bonding material. Heat slowly until boiling mad at Hitler and Tojo.

That is the formula for the best war equipment in the world. A year ago much German equipment was superior. Now the Germans themselves are awed by our weapons. At Normandy, praise of our weapons was on every German tongue.

Stated Lt.-Gen. Jacob L. Devers, deputy commander-in-chief in Italy: "On the Italian front our ordnance is far superior to any German ordnance I have seen. To us, most German equipment is obsolescent. I saw our M5 tank recently knock out a German Panther tank with 14 rounds because of the mobility of its turret. Our mortars have done exceptionally fine work, we lugging them up the mountains, where Germans had nothing to cope with them."

Old Time Materials vs. Upstarts

We have felt all along that the newly-developed materials will never upset drastically the long-established products such as steel and older nonferrous metals. Apparently L. S. Hamaker, assistant sales manager, Republic Steel Co., is of the same opinion. Thus, he stated recently that specially alloyed steels are already displacing aluminum in aircraft parts where aluminum's tensile strength is insufficient. "We'll have steel airplanes long before we have aluminum automobiles." Much of the excess light metal capacity will not find markets.

As to magnesium, corrosive qualities will tend to lessen applications and its problems of fabrication will be a handicap, Mr. Hamaker continued. As to plastics, molding difficulties and other characteristics will confine such materials to a scope that will not trouble the steel market.

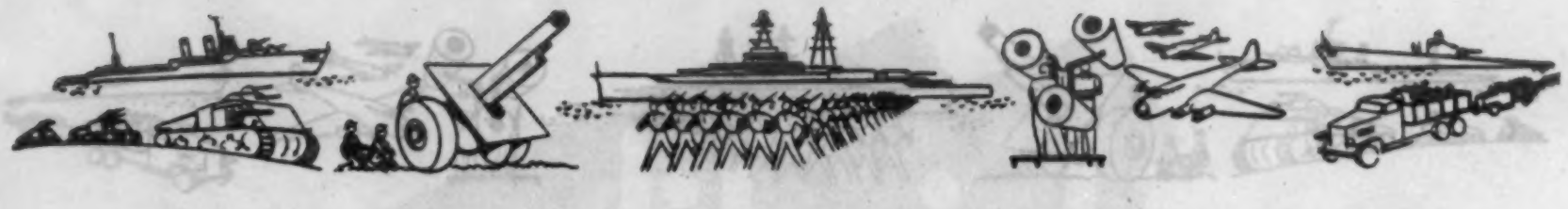
Plastics look like a gadget market —and steel never lived off gadgets. The lack of surface hardness in plastics, demonstrated by noses of bombers that clouded up after various strains, destroys the dream of plastic tops in automobiles. Screen cloths made of plastics are found palatable by rats. Plastic pipes have gone limp carrying hot water.

So He Calls Gold "Nothing," Eh?

Several of the smart minds at Washington have been appalled by the manner in which we are using up our resources during the war. An apparently growing school of thought is that we should import more and more to save our native resources for emergencies. Talking along that line recently was Dr. W. Y. Elliott, director, Office of Civilian Requirements.

"We should bring manganese, chrome, tungsten, etc. from rich mineral nations to store in the United States in return for Lend-Lease. We should import oil and put it in our own ground (an engineering feat which many oil men say is feasible). Such stocks would promote security, would be something tangible. These materials don't spoil."

In speaking of that metal which we have been storing at Fort Knox, Ky., he said: "Nothing is what you



have been collecting, importing and storing—and you called it 'gold'."

We Yawn at Manpower "Shortage"

Somehow we can't get alarmed and worked-up over the manpower shortage "crisis." One reason for our boredom is statements like the one following, issued, if you please, by Paul V. McNutt, himself:

"Increased productivity in the airframe industry has been beyond all expectations and is almost breathtaking. By Dec. 31, 1944 the labor productivity per worker is likely to reach four times what it was in January, 1941."

Philosophy on Metals' Future

We alleged journalists learn in the course of years the true spokesmen of industry and the false prophets. To be a true spokesman, one must not only have sound philosophies and ability to think through to the logical conclusion, but the happy faculty of putting it on paper. Such a fortunate combination resides in Clinton H. Crane, president, St. Joseph Lead Co., who spoke recently on "Lead—Past, Present and Future," before the Mining Club of New York.

Apparently with unerring perception he scents the trends of the future and is, perhaps, one of the first in this era to give voice to his perception. Moreover, what he said probably applies to more metals than lead—perhaps to American metals generally. We quote, somewhat at random, from his speech.

"It is axiomatic that the more valuable metals can travel further to market than those of less value, gold and platinum farther than silver, copper farther than lead, lead farther than zinc. A zinc mine in New York is a valuable asset, but the same mine in Africa would have no value whatever.

"Up to recently, the United States has been self-contained as to lead. We have the right to hope for continuing production from the major lead districts of the U. S. for a long future, with an adequate price. The rate of production, however, can never reach their former peaks. Producers in minor lead areas will continue to produce, but only at a much higher price.

"Lead must be imported to fill domestic needs, and to get this lead a higher price must be paid than during prewar. There is no question we must go farther afield for our lead and zinc, and we must pay a higher price to compensate for increased transportation costs.

"There is not a very great stock of war lead on hand, and there will not return to market any such abnormal amount of battle scrap as in War I, when many thousands of tons of shrapnel balls had to be marketed. World prices of metals must rise sufficiently to furnish us necessary supplies.

"I am not one who fears competition of plastics and lighter metals. All matter is composed of electrons whirling around protons. Each particular molecule is more suitable for some certain purpose than any other.

"No metal will really replace copper in the electrical industry; no metal can well replace lead for chemical work, cable sheathing, storage batteries and paint. No metal can replace zinc for galvanizing or die-castings and as a component for brass.

"There is a twilight zone in which all metals compete, but major uses are inherent in their structure. A metal must not only be suitable in structure, but in sufficient quantities. Before tetraethyl lead was developed, tellurium was equally or more effective, but quantity was too small.

"Finally, I think all should urge a taxing policy which will recognize the importance of allowing the lucky prospector to become a rich man."

Diapers for Wipers

By V. M. McConnell

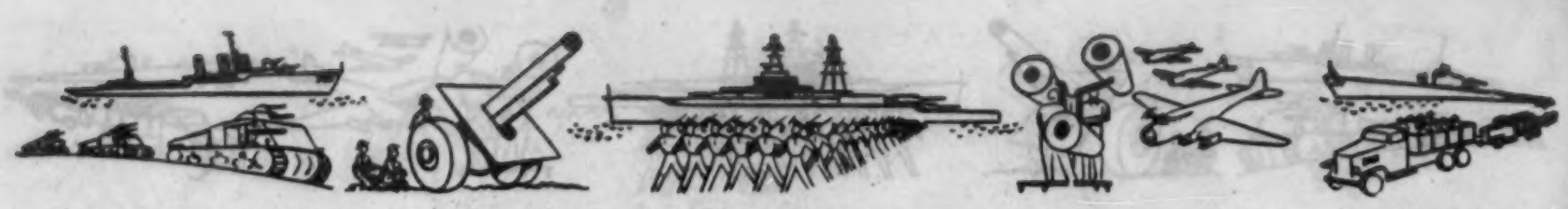
[*News item: Diapers have proved both fancy and useful in this war. When Uncle Sam, disguised as Santa Claus, sent diapers to Tunisia, the Arabs used them for turbans. Now Westinghouse finds them ideal to polish lenses.*]

The diaper the baby wore
In these environs urban,
Delights the Arab even more—
He wears it like a turban.
While Westinghouse,
Whose writers brag
Of scientific frenzies
Employs this self-same
Little rag
To polish up the lenses.

Gad, What Contrasts!

The *Olympia,* the flagship of Admiral George Dewey, now a battleship "black," instead of gray, because of the ravages of time, floated silently at the dock in a remote sector of the Navy yard that we visited recently. She had been stripped of all machinery, we had been told, and only missed the scrap yard because of historical and sentimental reasons.

Her last voyage was to bring back the "Unknown Soldier" from France's poppied fields. She had seen glorious days, such as when she brought Admiral Dewey to New York for the triumphal march up Broadway months after the battle of Manila Bay.



But what makes the *Olympia* a pathetic little hulk by contrast is the new super battlewagon, "largest in the world," they told us, about a mile and a half distant. When we saw her in the sunlight she had already been commissioned. By now she may be at sea stalking the little yellow men.

Telling more details would be violating military secrecy—we weren't told many details though our eyes saw aplenty. What an inferno she will create with those hundreds of guns, big and little, belching flame and perfectly-aimed death!

She may be repainted several times —with a bluish tinge when she enters blue waters and a greenish tinge for greenish waters.

It is battlewagons like this that will go far in making Tojo and his war lords eventually bow and say: "So sorry, please." But this time their "Sorry" will be genuine, and not a cloak to hide nefarious plots.

The Versatile Diaper

Perhaps one of the heartiest chuckles of the war was our sending of huge quantities of babies' diapers to Tunisia in the early days of the campaign there, the purpose apparently being to build up civilian morale there. Meanwhile, American mothers encountered severe shortages here.

To cap the climax, the diapers found their way into the hands of—or rather onto the heads of—Arabs, who used them as turbans, which they wore at a jaunty angle. Thus, while many an American babe was sans pants, many an Arab strutted his stuff in market places with a spotlessly white turban, fashioned with skillful fingers from the good old American diaper.

But by now a more practical use has been found at home—and doesn't charity properly begin at home? Three thousand diapers monthly are used at the Electric Appliance Div., Westinghouse, Mansfield, Ohio, to clean and polish glass lenses for army binoculars and tank telescopes. They are absorbent, leave no lint, and are ideal for removing tiny specks that might mar vision.

Footnote to mothers: Westinghouse launders the cloths so gently that they can be used 700 times.

Artillery, Exit! Rockets, Enter!

"The end of the war will be hastened by the effectiveness of American artillery-type rocket projectiles", according to C. Donald Dallas, President of Revere Copper & Brass, Inc., in releasing the news that for the past two years rockets have been turned out in tremendous quantities by the Rome Mfg. Co. Div. of Revere, Rome, N. Y.

Rockets already play a more important role in this war than the public generally realizes. A large share of the shooting during the invasion of France was by this type of weapon, launched from landing craft, tanks, paratroopers' tripods and infantrymen.

American-type rockets have also been used effectively on the Burma and Chinese front.

Chief advantages of its use is light weight of rocket and launching tube and absence of recoil. A further advantage is that when it hits its target it is still being driven forward by nascent power, whereas a shell merely travels on the impulse received a few seconds previously—and no longer being generated.

The United States is considerably ahead of the Germans in the development of the Rocket. The latter, always ponderous in their conceptions of things, build their rockets and guiding fins too heavy. A feature of our rockets is the collapsible guiding vanes on the tail.

At the time of insertion into the launching tube these fins fold up, much like the wing of an airplane when stowed on a carrier. Upon leaving the launcher tube, these fins spring out into much the same position of an airplane propeller, guiding the rocket to its target and keeping it from whirling.

The rocket launcher in the hands of the infantryman is aimed like the average gun, having sights at the end of the tube. In an airplane it is often placed parallel to a .50 calibre machine gun and so connected with that gun that by aiming and firing the gun the rocket goes off at the same target.

There are several sizes and descriptions of the missile, depending on the service involved. The typical projectile is about 2½ ft. long and of 4½ in. diam. In the nose is a fuze that regulates time of explosion. Behind this is the T.N.T. or other explosive. Further behind is the propellant powder of the rocket. The rocket is set off either by impact of the trigger mechanism, as in the conventional gun, or by electrical spark from a small storage battery.

The typical rocket is made at the Rome Mfg. Div. plant of Revere Copper & Brass, Inc., of SAE 1025 steel sheets that are bent into tube form, then seam welded into the completed tube at 40 ft. per min. Thereafter the tube is placed in a die, the walls made thinner by cold working and with increases in the physical properties of the tube.

The extrusion process for making seamless tube was found inferior, since the interior of the tube was difficult to work upon to improve the steel.

The typical sized rocket is equivalent in destructive power to the shell of the popular 105-mm. howitzer, the "work horse" of the army. Chief advantage of the rocket is its lightness and ability to serve in a very mobile and fluid warfare. Weighing around 50 lb., it is easy to take to inaccessible terrains such as mountain tops, swamps and jungles.

An interesting application of another rocket—the so-called Target Rocket—has been in anti-aircraft gun practice. Target rockets, with large wooden fins, are hurtled through the air and shot at by gun crews, much like shooting skeets.

Unquestionably, the aim of British and American anti-aircraft gunmen in shooting down German "buzz bombs" over England has been improved by practice on this type of rocket target, which closely simulates the flight of an airplane.

Copper in the War Effort

Claims have been made for many products that the present war could not be fought without their use. And this is true of many materials—steel, aluminum and magnesium, zinc, lead, copper and its alloys, and so on.

"An army without copper would be an army without speed, maneuverability, communications, or fire power—it would not last a day in battle." Under Secretary of War Robert Patterson is credited with this striking statement. Surely copper, brass and copper base alloys are vitally essential in the prosecution of any war. Speedy transportation, intercommunication, and fire power are dependent on copper in one form or another.

An impressive picture of the role of copper and its alloys in transportation has been published in a bulletin by the Copper & Brass Research Association. And transportation is a potent factor in the modern type of mechanized warfare. Considerably more than a billion and a quarter pounds of copper and its alloys are in service today on American railroads which "last year made as phenomenal and unique a record as any achieved in the entire history of transportation." Copper is the nerve system of all railway transportation.

Depending on the type of ship—passenger or battleship—there are from 2,000,000 to 3,000,000 lb. of copper and its alloys in each one. Substantial quantities of these materials are used in the construction of tanks, trucks and jeeps, highly essential factors in modern war. And in airplanes copper and its alloys play a vital role. Many other essential uses could be cited.

But necessary as copper is to the prosecution of a modern mechanized war, it is only by the combined contribution of this metal with several others that the campaigns can be carried on, and victory for allied arms assured. No one metal or product is sufficient unto itself.

—E. F. C.

Broad Plans for Post-War Metals

The United States has enough base metal above ground to last three years in peace time, if not an additional pound were mined and refined, states a reliable authority. In harmony with this observation is the statement from another quarter that world supply of copper above ground is equivalent to four years' consumption.

Many now in the metal industries recall conditions after the first world war. Surplus copper was a terrific thorn in the flesh until bonds were floated to form a pool, the copper being released gradually upon the market. To handle steel that was running out of the industry's ears many fly-by-night merchant firms sprang up. This was upsetting to the industry, with prices demoralized and the ethics of the industry violated. In tin an international pool was formed which functioned with a fair measure of success. Only recently an expert economist has stated that tin has been one of the few successful cartels.

A new factor has come into being in the form of Government stockpiles. Theoretically, these will accomplish in a logical manner what other schemes have failed to do. But of course there are certain drawbacks. The knowledge of the existence of surplus metal tends to tear down market morale and prices. A change in administration might mean the throwing

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BUY U. S. WAR BONDS

RYERSON

overboard of these stocks. Moreover the public may become complacent on permanent peace prospects just as they did after the first war.

Unfortunately, if history repeats, some metals may again be the core of a political football, such as lavish mining of silver has been among the silver-producing states.

Another new theory has sprung up since the first world war, to the effect that we cease to mine our own diminishing metals lavishly, but rather systematically import metals from countries where supplies are more abundant.

"The United States no longer enjoys self-sufficiency in zinc and the deficit in the post-war years may range upward of about 200,000 short tons a year," stated Thomas H. Miller, chief, Metal Economics Div., Bureau of Mines, before the April meeting of the American Zinc Institute. Moreover, the same authority in an article in "Minerals Yearbook," published by the Bureau of Mines, presents a table that shows how the yield of copper ore diminishes almost continuously as our ores become leaner. Thus the average yield in 1935 was 1.89%; in 1936, 1.54%; in 1937, 1.29%; in 1938, 1.34% and in 1939, 1.25%. As to iron ore, it has been stated by several experts that our 50% ore is limited in supply and that before many generations have passed we will be forced to use 30% iron.

Hence there are many factors to be weighed in framing Governmental post-war plans for metals. Perhaps the wisest conception will be the realization that the United States is no longer an apparently unlimited source of metals. It may be that our field in the future is to be one of skilled fabrication of metals in large measure imported. We have progressed far in technique. Perhaps we had best capitalize on those techniques. Thus in the early days our own New England had limited native materials, but reached eminent position in affairs of manufacture and commerce because of her skills. —H.A.K.

Factor of Safety vs. Facts

New ideas of design, based upon the fact that materials in fast-moving machinery will fail ultimately at loads below their maximum strengths, have been given a tremendous impetus by the aircraft industry. Designers, faced with the knowledge that the "factor of safety" would no longer cover their lack of definite data upon engineering properties of materials, have called for these data, and research laboratories have responded.

We now have more data about fatigue endurance, damping capacity, high- and low-temperature properties, etc., than ever before, and these factors are beginning to enter actual design calculations. In an airplane, each pound of weight requires wing area or horsepower to support it in flight, so that it is extremely important to work materials at loads as close to their maximum strengths as possible. At the same time, human life depends upon the adequacy of the material. Obviously there was a desperate need for dependable data upon these rather vague characteristics.

The automobile industry had begun to consider fatigue endurance years ago. Some idea of what fatigue means in an automobile may be obtained from a statement by J. O. Almen, of General Motors Corp., that a car subjected to maximum load continuously would last for about 30 miles. The difference between 30 miles and 100,000 miles represents the difference between fatigue endurance at maximum load and fatigue endurance at ordinary driving conditions.

Defects located in rails last year were about 40 per cent above the previous worst year, according to an engineer for a rail testing service. In view of the increase in the number of railroad wrecks, this statement is enlightening. That it is not the fault of the rail manufacturers is shown by his opinion that "about 99%" of these defects were the result of fatigue.

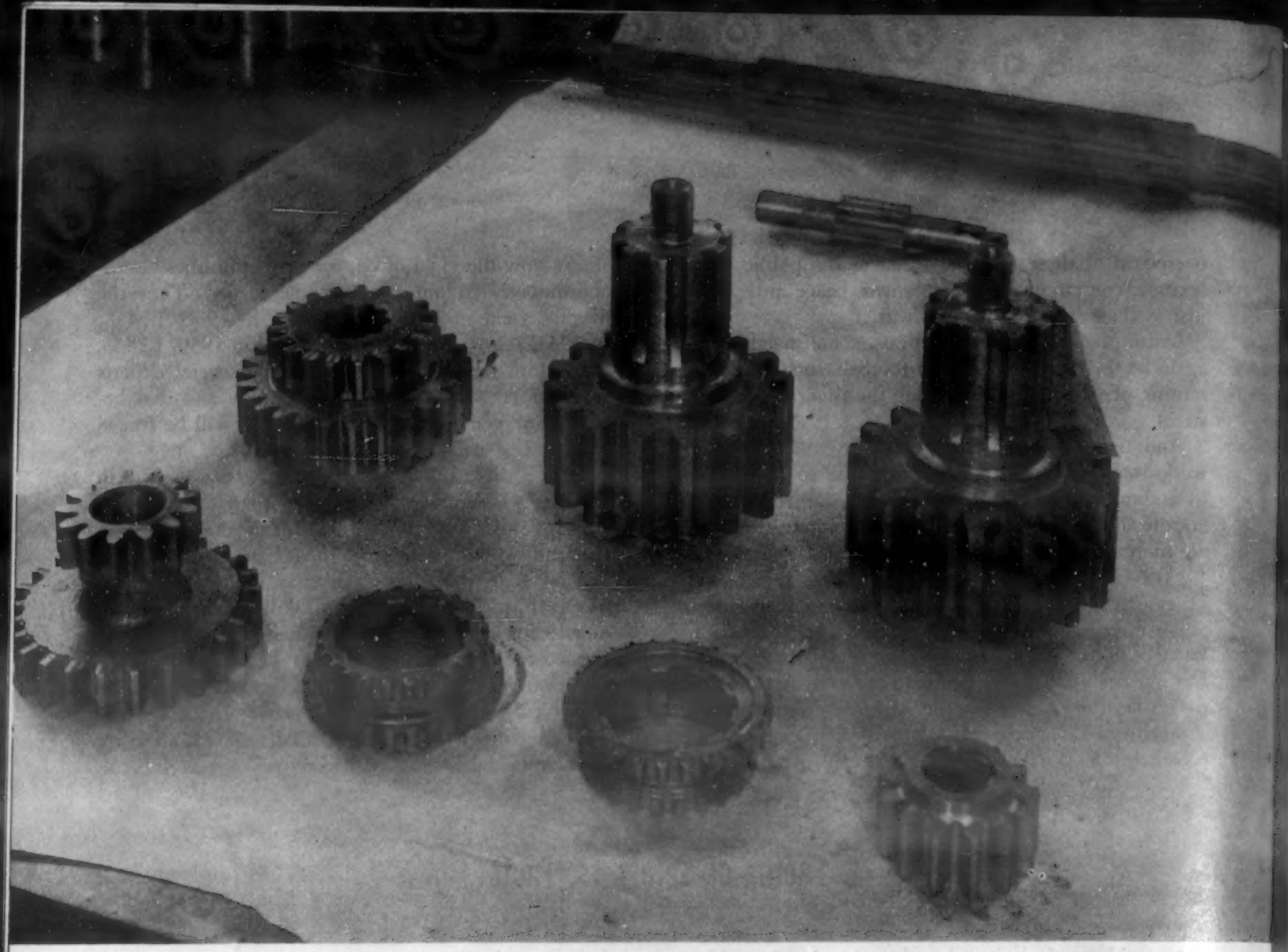
We have much to learn about these newly emphasized properties of materials. Data are being collected which will give the designer in every line an opportunity to design more accurately. We may, in the near future, say goodbye to the factor of safety insofar as it was a factor of ignorance, and design parts on the basis of sound engineering facts. —K. R.

Steel Castings—Progress in Heat Treatment

The advances that have been made in the last thirty to thirty-five years in the development and improvement of heat-treating technique for steel castings approach the sensational. Three stages mark this development or evolution.

During the first stage steel castings were considered fully annealed only if they had been thoroughly heated just above the recalescence point and held in a closed furnace until they had cooled to room temperature.

(Continued on page 88)



Tractor gears successfully carburized in electric salt bath furnaces.

Liquid Carburizing of Transmission Gears

by W. A. Silliman

Metallurgist, Cleveland Tractor Co., Cleveland

Heavy duty tractor gears and parts must be carburized and heat treated to unusual combinations of toughness, wear-resistance and fatigue strength. The properties of course must be uniform from piece to piece, but in addition distortion must be held to an absolute minimum. At the Cleveland Tractor Co., because of distortion, considerable difficulty was met in keeping rejections at an economically low level, until the parts were treated in electric salt bath furnaces, which not only solved the distortion problem but also resulted in increased production and other benefits. —*The Editors*

ONE OF THE CHIEF ADVANTAGES of salt bath heat treatment, especially if the bath be heated electrically, is the uniformity of heating obtained. An important practical result of this is that parts treated in salt baths are likely to suffer only a minimum of distortion, and the method therefore recommends itself for situations where distortion is a serious problem.

At the Cleveland Tractor Works one such problem had existed for some time in the carburizing of such parts as transmission and differential gears, stem pinions, spline shafts and other heavy duty tractor parts.

These parts were formerly gas carburized in batch furnaces, slow-cooled and then reheated and hardened. The scrap from this operation would often run as high as 10% rejection because of distortion. Since the changeover to salt bath practice the scrap attributable to distortion has been reduced virtually to zero and output has been boosted considerably. Because other engineers may find our experience helpful we are giving here the details of our problem and of our experience with the electric bath process as a solution.

Former Practice vs. The New

For the gears and shafts in question we have used a variety of steels—S.A.E. 5120, 4620, 4820, X 1020, NE 8620, 9420; 1010 for washers; and even 2315 and 2512. As previously mentioned the work was gas carburized, slow-cooled, reheated and hardened. Some parts were quenched on spline plugs to maintain their size.

The former practice in carburizing consisted of loading the work onto special alloy jigs and fixtures and handling on alloy trays. The trays were then charged into a batch type gas carburizing furnace which would accommodate six trays, approximately 13 in. x 26 in. per tray. The total charge of fixtures and work was approximately 1500 lb., of which 300 to 500 lb. of the charge was alloy fixtures. This required a minimum time of 2 hr. for the work to come to heat in the furnace before carburizing could start. The gas carburizing cycle was then 6 hr. This was necessary to insure satisfactory minimum case depth. Variation in case depth was due primarily to variation in furnace temperature throughout the furnace.

With the batch type method of carburizing it was necessary to accumulate the whole charge of work for the furnace in order to get economical operation. In the case of rush work it was often necessary to lose valuable furnace time because of the need to hold the furnace ready for rush jobs that had to be delivered to the assembly line the following morning.

Distortion was an ever present problem. In one specific instance of scrapped parts (the spool gears), the scrap in some instances would run higher than 10%; by the salt bath method one piece out of 110 pieces was scrapped, merely because it was dropped in handling. Actually the reduction of scrap has paid for the salt bath furnaces. When we developed a high speed transmission, which was foreign to our shop prior to the war contracts, our scrap ran as high as 50% on many of the gears. This was in part due to the closer tolerances required for the gears. Since liquid carburizing, our scrap has been less than 1/10 of one percent.

We have found that with this salt method of carburizing, distortion has thus been reduced to a minimum, and where it was necessary to plug quench gears by the former method in order to maintain size, it is now possible to run all of these gears by direct quench from the bath without plug quenching. Distortion is now measured in ten-thousandths as compared to thousandths by former methods. We attribute this reduction in distortion-spoilage to the fact that we are getting more uniform heating of parts and more uniform quenching than was possible with the previous equipment and method of handling.

We preheat no parts, other than the incidental preheating that occurs when they are hung against the surface of the furnace to dry off moisture that may be there. The floor space now used for liquid carburizing is about one-fourth the space required to do the work by former methods. Finally, the normal cycle of operation was cut from an 8-hr. carburizing cycle to 4 hr. total time (aided by the direct quench now used, as described below) thereby saving the reheating time and labor for hardening the parts.

There was no change in steel specifications necessary to convert from gas carburizing to liquid carburizing.

Furnace Equipment and Practice Now Used

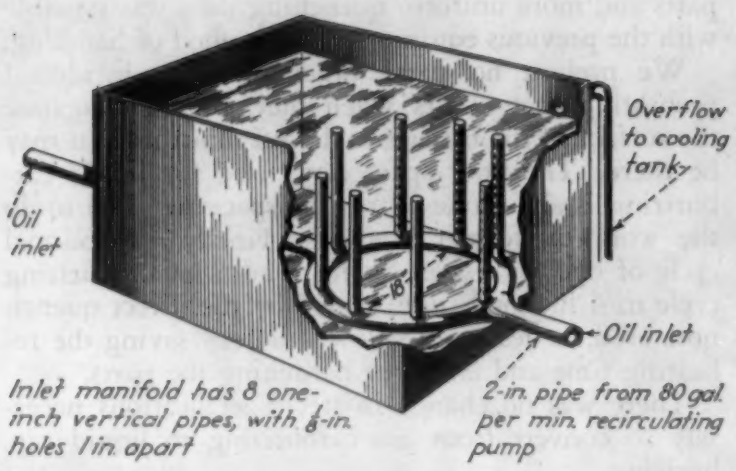
The salt bath furnaces now in use consist of 3 standard Ajax-Hultgren closely spaced electrode furnaces made by Ajax Electric Co., Inc. of Philadelphia. The large furnace has a bath working area of 72 in. x 20 in. x 24 in. and a rating of 90 kw. The smallest furnace of the group has a working bath area of 24 in. x 15 in. x 14 in., with an input of 35 kw. There is also a 75 kw. furnace with a bath working area of 48 in. x 20 in. x 16 in. The large furnace has been operating about a year; the others have been in full operation for nearly 3 yr.

We bought the first two furnaces with the idea of carburizing in one furnace at 1650 F. and stabilizing the temperature at 1450 F. in the smaller furnace before quenching, feeling that this would give us a minimum of distortion. However, it was soon proved that gears direct quenched from 1650 F. showed approximately the same distortion as gears which were transferred to the furnace at a lower temperature and then quenched. So production was materially increased by adopting the direct quench procedure, thereby placing both furnaces in production and giving us a maximum output of work at a time when it was greatly needed.

In the salt bath method of carburizing, the loading of the pots is staggered so that work is being charged and removed from the furnace every hour. By using the stagger system a small volume of cold work is entering the furnace each hour, and the heat recovery is very rapid, with a maximum of 15 min. on heavy parts. The temperature drop seldom exceeds 25 F.

The salt used is Perliton 60X, a product of E. F. Houghton & Co., Philadelphia. The X signifies that the salt provides extra carbon to maintain the blanket at higher temperatures.

The strength of the salt bath is maintained by predetermined additions of salt at 4-hr. intervals. The cyanide strength of the bath is checked twice daily, at 8:00 a.m. and 4:00 p.m. in the afternoon. Any major adjustments of the bath are made at this time. However, it is seldom necessary to make any sizeable additions at these checks. The bath is held at a cyanide concentration of 16 to 18%. This is a reduction of 8% over the original set-up when the furnaces were put into operation. We have found that at this lower concentration the salt is more stable.


Overflow to cooling tank
Oil inlet
Oil inlet
Inlet manifold has 8 one-inch vertical pipes, with 1/8-in. holes 1 in. apart
2-in. pipe from 80 gal. per min. recirculating pump

Submerged oil-spray quench fixture.

The carbonate sludge which forms in the bottom of the pot is scraped loose and removed every morning. This tends to eliminate excessive localized boiling and facilitates in maintaining a good uniform blanket over the surface of the bath. Should a hot spot occur during the remainder of the day, the carbonate sludge is removed from that part of the bottom. The hot spot referred to is a localized break in the blanket of the bath where excessive fuming or breakdown of the carburizing salt occurs.

In general the case depth specifications remain unchanged. Most of the lighter gears carry a case depth specification of 0.030 to 0.045 in. About 0.038 to 0.040 in. is the average with the salt method of carburizing. With the salt method of carburizing we have found that we can maintain a much closer control of depth of case. The maximum cycle employed is 7 hr., which produces a case depth of 0.050 in. minimum.

Carbon Steel Fixtures Successful

Fixtures for handling the work are fabricated in our own shop from mild steel plate and rod which is welded to give us the desired support. It was originally planned to use these fixtures as pilot samples to determine which would be the most practical design to use. However, the life of these fixtures has been surprisingly good, and it was found to be more practical to use these carbon steel fixtures rather than to purchase pattern equipment and special alloy fixtures. These fixtures have lasted 6 mos. to a year. One reason for this exceptionally long life is that all the fixtures are used in oil quenching.

Frequently one hears objections to the use of salt as a medium of carburizing or heating parts that are subsequently quenched in oil, the chief objection being to lower hardness or spotty hardness of the work, caused by the salt film that adheres to the parts when they are removed from the bath. This drawback is overcome at The Cleveland Tractor Co. by using a submerged oil-spray quench fixture, a sketch of which is shown.

The oil tank is about 3 ft. x 3 ft. x 4 ft. The largest gear quenched in the tank is a spool gear approximately 15½ in. in diameter at the large end and weighing approximately 75 lb.

Large gear being placed in Ajax-Hultgren electric salt bath furnace, for carburizing.

In the quench fixture (see the accompanying sketch) there are eight vertical 1-in. pipes disposed in a circle of about 18 in. inside diameter. The pipes are 33 in. long, with ⅛-in. holes drilled at 1-in. intervals the whole length of pipe. The manifold pipe is approximately 2 in. in diameter. Oil feeds into the manifold at two points 180 degrees apart. The rate of oil flow in this system is approximately 80 gal. per min.

Incidentally, through the use of some simple and quickly-made fixtures and a change in salt, we have on occasion used our salt baths for other work. Thus in one instance it was necessary to normalize some sheet metal stampings that were a high production item, and which did not lend themselves readily to the sand blasting method of cleaning. After worrying along for a week with the conventional method of furnace heating and air cooling followed by sand blasting, it was decided that a more economical and better method of treatment could be devised.

We converted one of the carburizing baths over to a neutral salt and by the use of some simple welded fixtures were able to heat the parts in salt, and to cool in air without scaling, by virtue of the film of salt adhering to the pieces. When the parts were cooled they were washed free of salt, dried, and ready for production. The changeover was accomplished in 8 hr. and the material-handling time was considerably reduced.

Auxiliary Equipment and Operations

The original electrodes are still in operation in the furnaces and in good condition. One pot has been replaced in each of the original furnaces; the first one went out faster because of carbonates and salt creeping over the edge of the pot. It was found necessary, when a new pot was put into operation, to retighten the bolts attaching the copper bus bars to the electrodes after the furnace had been up to temperature at least 24 hr. This will insure against arcing and pitting of the copper bus bars and electrodes.

Gears are direct-quenched from the carburizing temperature into oil with good results.

The temperature controls are indicating controls operating on a 5-deg. spread. Temperature does not vary more than five degrees except during charging time. The thermocouple and potentiometer combination is checked by means of an optical pyrometer. This is done by breaking a hole in the blanket and taking a reading on the molten salt. In case of a discrepancy between the indicating controller and the optical readings, the bath is checked by means of a potentiometer and a new thermocouple. If the controller reading is not in agreement with the potentiometer within 5 degrees, we then check the original couple and usually find that it needs to be replaced. The control instrument is checked and serviced every 60 days.

All carburized parts are washed in a hot alkaline cleaner solution after quenching and are tempered at 350 F. for 1 hr. This method of treatment enables us to maintain the 58-63 Rockwell C required.

We have found sand blasting especially useful in preparation of finished parts for grinding. This preparatory treatment is necessary because of the type of grinding wheels on hand and the lack of availability of suitable abrasive wheels. Having standardized on an especially effective type of grinding wheel, the company's engineers were unwilling to change when it was found that salt-hardened gears glazed the wheel. Instead of changing to a type of wheel that would not glaze under these conditions, the engineers decided to sand blast; this proved to be the solution, and it was not necessary to change the grinding wheels.

Production Output and General Results

With the salt bath method of treatment and using the stagger method of loading described earlier, production can be maintained at a constant rate, whether or not there are rush items to be gotten out. In the extreme case, any rush work is never held up for more than an hour before it is charged into the furnace. In the two small furnaces in December 1942 and January 1943 we produced over 38,000 lb. of gears per month. This represented 86,041 pieces of work, all handled on a 4-hr. cycle. From August 1942 through July 1943 we carburized a total of 339,229 lb. of gears, all on a 4-hr. cycle.

For this particular type of work we can state that the changeover to salt bath carburizing has solved our major problem of avoiding a high proportion of rejects caused by distortion, and has in addition provided us with higher output rates.

To date we have had no failures in the field; the service record is not old enough to show the notable improvement in the life of the gears which we expect to find. The steels used during that time have undergone such changes because of their changing availabilities that no clear-cut statement on gear performance can probably be made, anyway. In a clash test, we have found the liquid carburized gears to give better service and less spalling than gears treated by the previous methods.

GETTING THE MOST OUT OF

Electric Steel Furnace Electrodes

by R. L. BALDWIN *National Carbon Co., Niagara Falls, N. Y.*

Electric steel melting furnace operators and engineers can do many things that may either increase or decrease the pounds of electrodes consumed per ton of steel melted. This very practical article is a collection of such do's and dont's—handling methods, joint-assembly techniques, electrical conditions, operating practices, etc.—to extend the life of graphite and carbon arc-furnace electrodes. —The Editors

THE MANUFACTURE OF ELECTRODES for electric steel furnaces is a science as exacting as that of making steel itself. That they are made from materials of practically no inherent strength, in sizes up to 40 in. in diameter, weighing thousands of pounds, and are capable of performing their function efficiently under the severe conditions of electric furnace operation, represents a distinct engineering achievement.

The electrodes are raised up through the roof while a charge is being put in the bath. (Courtesy: Timken Roller Bearing Co.)

Through the years since the inception of the electric steel industry, research and experiment have constantly improved the mechanical strength and operating efficiency of electrodes. A single instance of this electrode improvement may be cited from National Carbon Co., Inc. data which shows that where 40 to 50 lb. of amorphous carbon electrodes were consumed for each ton of steel ingots produced 25 yr. ago, present consumption of electrodes per ton of steel averages approximately 23 lb. This is true even in the production of the highest grade alloy steels.

Engineering achievements in electrode manufacture, however, do not mean that care need not be exercised to prevent damage to electrodes through abusive handling. Such care is taken by manufacturers to guarantee that electrodes will reach furnace operators without abrasions or damages that would mean faulty and expensive operation. From the point of delivery and on through the melting process, the responsibility for proper care and use of electrodes is solely upon the operator.

Proper care and use of electrodes may be divided into seven major categories. They are:

1. Handling and storage
2. Joint assembly
3. Charging
4. Influence of electrical conditions
   a. Transformers
   b. Regulators
   c. Electrical characteristics
5. Thermal factors
6. Excessive oxidation
7. Mechanical breakage
   a. Loose gallows arms
   b. Off-center cooling rings and roof
   c. Poor electrical contact with charge

Handling and Storage

Electrodes leave the factory with surfaces in proper condition to permit good contact with electrode holders and with the end faces and threading accurately machined to ensure effective joints. Surface abrasions or chipped end faces result in poor electrical contact and minimize electrode effectiveness as a current conductor.

For this reason great care should be taken to prevent breakage, chipping or marring during delivery in railroad cars and during removal from box cars at the mill. Storage should be provided in the form of well-designed racks, preferably of steel. Where a steel rack is not possible, 2 x 4 in. timbers should be placed on the floor and the electrodes stacked evenly upon them, with additional timbers separating the electrode layers. Where shipments are in less-than-carload lots, the boxes in which the electrodes are packed should be moved on rollers or by hand truck and not by turning end-over-end.

Normally, cranes are available for moving electrodes from racks or piles to the furnace. If not, a set of chain blocks suspended from a trolley on an I-beam should be rigged for the purpose. To lift an electrode from its horizontal storage position to vertical furnace position, use only a steel lifting plug threaded to screw into the threaded electrode end. The plug should be equipped with a swivel eye to facilitate the turning of electrodes during joint assembly.

Nipples are important to the performance of electrodes. They are shipped in cartons, and should not be removed from these containers except when needed for joint assembly. Electrode joint compound used in carbon electrode joint assembly is shipped in sealed containers holding 50 lb. These, too, should be stored in a warm place and should remain sealed except when in actual use. If the container opened for use remains uncovered, the compound will become contaminated by dust and other extraneous matter.

Graphite Joint Assembly

If a single factor relating to the use of electrodes could be termed "most critical," that factor would probably be joint assembly. Mechanically, the joint is the weakest part of an electrode. The joint is the only part of an electrode where electrical conductivity, or resistance, is not predetermined and fixed in the manufacturing process. Both the mechanical strength of an electrode and its electrical resistance are to a very large degree dependent upon proper joint assembly.

A loose joint means a weak joint. It also means that the nipple may have to carry the entire electrical load, which in cases of high current density, makes for waste of power at the joint sections. The tighter the joint is drawn, without fracturing, the better. On an electrode 10 in. in diameter, for example, one man pulling hard on a chain wrench with a 48-in. handle would make a satisfactory joint.

The following rules for graphite joint assembly are extremely important:

1. Use compressed air for all cleaning operations.
2. Blow dust and loose particles from socket at upper end of the electrode in the furnace. When conditions are particularly dusty it is advisable to first brush end faces and sockets with a fine wire brush.
3. Clean new nipple of dust and loose particles. Carefully screw it as far as possible into the cleaned electrode socket. Avoid chipping threads and cross threading. Make certain nipple is firmly seated.
4. Carefully screw lifting plug into socket of new electrode and carry to furnace with crane hoist. Blow dust and loose particles from bottom socket of new electrode.
5. Swing new electrode into position directly over electrode in furnace and lower until nipple is just entering bottom socket of new electrode. Turn new electrode round and round and at the same time slowly raise the electrode which is in the holder, using hand control on regulator to raise electrode. Screw down until end faces are ⅛ in. apart. When joining electrodes, make sure that the new electrode is always supported on the swivel hook attached to the crane so that no weight is thrown on the threads of the nipple. Use an assembly wrench for all turning operations.
6. Blow dust and loose particles from between faces and then bring the faces together by applying a slow, steady pressure on the wrench.
7. Give two quick pulls of wrench to complete tight joint assembly. The contact end faces of the electrodes must be tightly together.
8. Still suspending the whole electrode assembly from the crane, loosen the electrode holder and run it up past the threaded section of the new electrode.
9. Never tighten electrode holder directly on the joint between two electrodes.
10. Keep joint tight at all times.

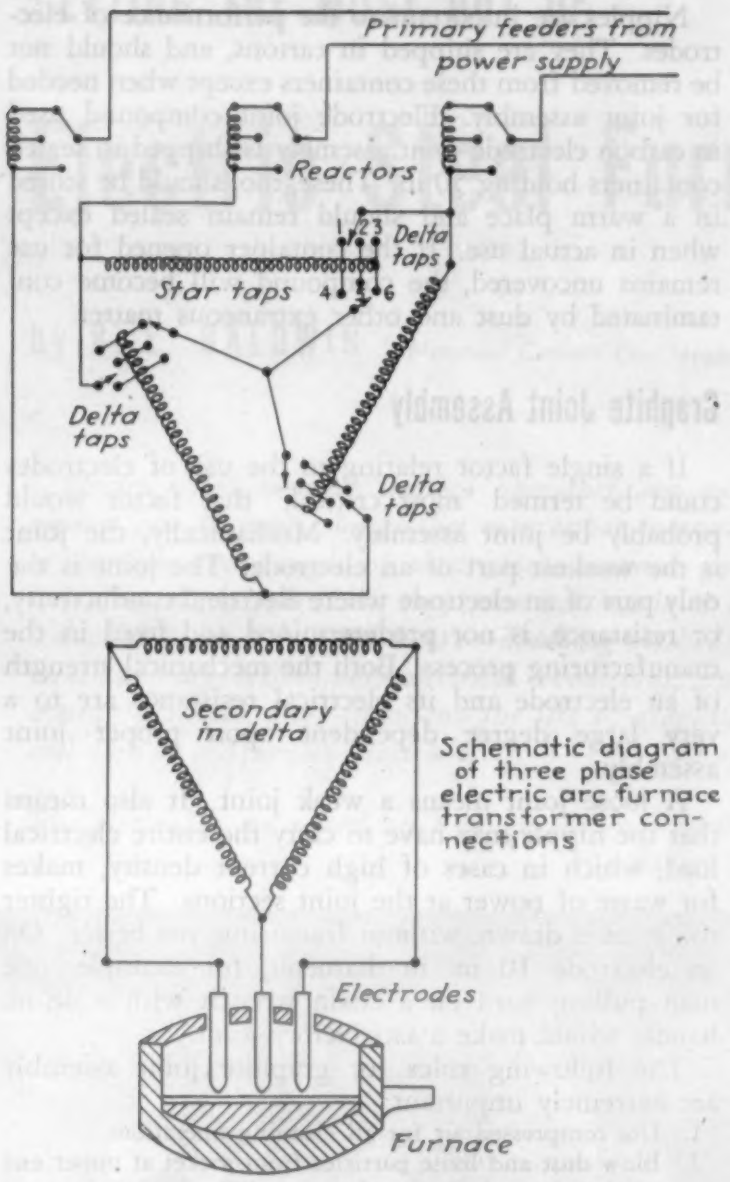


Fig. 1. Schematic diagram of three-phase electric arc furnace transformer connections.

It has been found that operators sometimes find difficulty in maintaining tight electrode joints when using large diameter graphite electrodes, and when operating at high values of voltage and current, as the high voltage and current induce severe vibration in the electrode supporting structure. To remedy this, a simple and effective solution called "pegging" has been adopted. Pegging is accomplished as follows:

1. Assemble the joint in the conventional manner, drawing it up as tightly as possible.
2. Drill a ½-in. hole exactly at the interface of the electrodes with a portable high speed drill. The center line of the hole should be radial in direction and should coincide with the plane of the interface as closely as possible. The hole should extend approximately 1 in. into the nipple, making a depth of 4⅜ in. from the periphery for 18-in. electrodes with standard size nipples, and 5⅛ in. for 20-in. electrodes with standard size nipples.
3. Insert a ½-in. graphite rod (Standard centerless ground to 0.500 in. max. is recommended) to the full depth of the hole and break off any protruding length. Regular ½ in. x 12 in. stock is recommended, one piece making two joints.
4. Should it ever be necessary to take an electrode joint apart, the peg should be drilled out. When and if the same joint is re-assembled, the resulting abrasion of the threads will probably allow it to be tightened a slight part of a turn further than the initial assembly. Therefore, it is always a wise procedure to drill a new hole on a re-assembled joint.

Carbon Electrode Joint Assembly

Assembling joints on carbon electrodes differs from that of graphite in that a joint compound is required to fill the clearance between the nipple and the threaded electrode socket. The compound also serves as a lubricant in seating the nipple in the socket. Some of these (e.g. "National Joint Compound") are highly developed products, perfected to flow and adhere as desired, to withstand the high temperature of an electrode joint, and to provide a residue of high electrical conductivity that will bring the resistance of the joint as near to that of the electrode itself as can be achieved. In assembling carbon electrodes, the rules already listed for graphite joints should be met, in addition to the following:

1. The joint compound should be thoroughly mixed in the container in which it is received. An amount sufficient to make several joints should then be removed to another pail and thinned with water to a creamy consistency.
2. If the electrode in the furnace is very hot, it may be desirable to thin the compound further by adding a cheap grade of molasses. Do not use water for this second thinning operation as the heat of the electrode will cause steam to form and blow the compound from the joint.
3. Dip the nipple into the compound to about two-thirds of its length. Let excess drain off into pail.
4. Screw nipple into upper end of the electrode in the furnace until it is firmly seated against the bottom of the threaded socket.
5. Apply compound by hand or with paint brush to upper end of nipple.

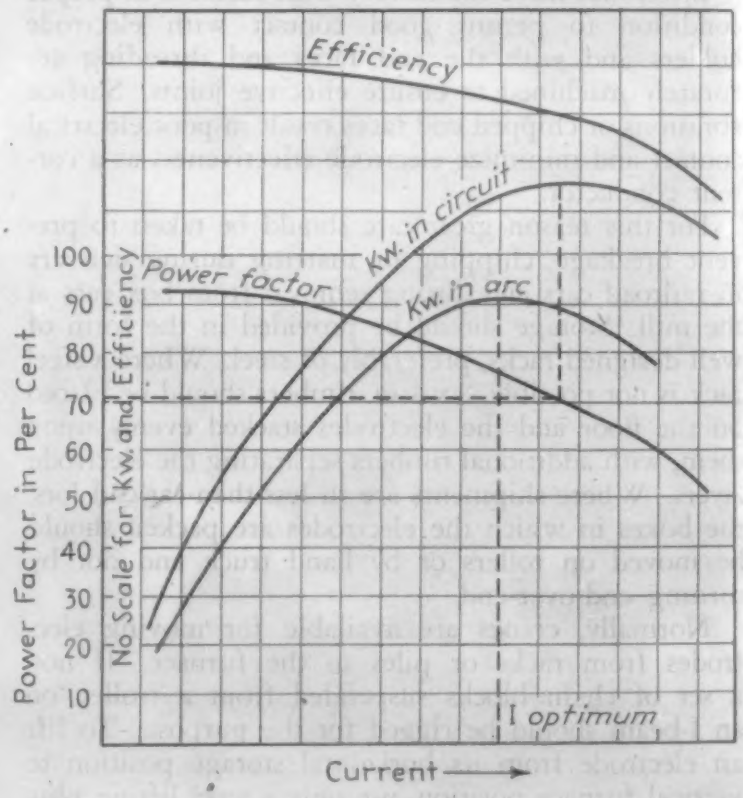


Fig. 2. Electrical characteristics of a typical steel melting arc furnace.

6. After swinging new electrode into position with crane and turning onto nipple, screw down until the two faces are about ¾ in. apart. Then spread a thin film of joint compound over electrode faces until they are entirely covered.

This completes the application of the compound. The joint may now be tightened as previously described.

Charging the Furnace

Much of the mechanical breakage of electrodes while in the furnace, if joints have been properly made, is a result of charging. There are four methods of charging electric furnaces: Hand, chute, charging machine, and top (with drop bottom bucket.)

Whichever of the methods is used, except in top charging where electrodes must be raised to clear the furnace, electrodes should always be raised to the highest limit to avoid the possibility of being hit in charging. Particular care should be exercised in chute charging, as when the furnace is tilted, the weight of the electrodes places an added strain upon the joints. This makes the electrodes highly vulnerable to breakage from the flowing scrap.

Most operators have their own formulas for charging, in which the efficiency of electrodes is a single element. In all cases, however, light, clean scrap should be present upon the surface for good contact. If electrodes are forced to arc on large chunks of scrap, an interruption in the circuit may force the electrode against a slanting surface and the leverage act to shear off the nipple. If large chunks of scrap are charged around the banks, there is a danger of their rolling down against electrodes and causing breakage during the melt. If it becomes necessary to bar them off the banks, this should be done with caution to prevent the same thing happening.

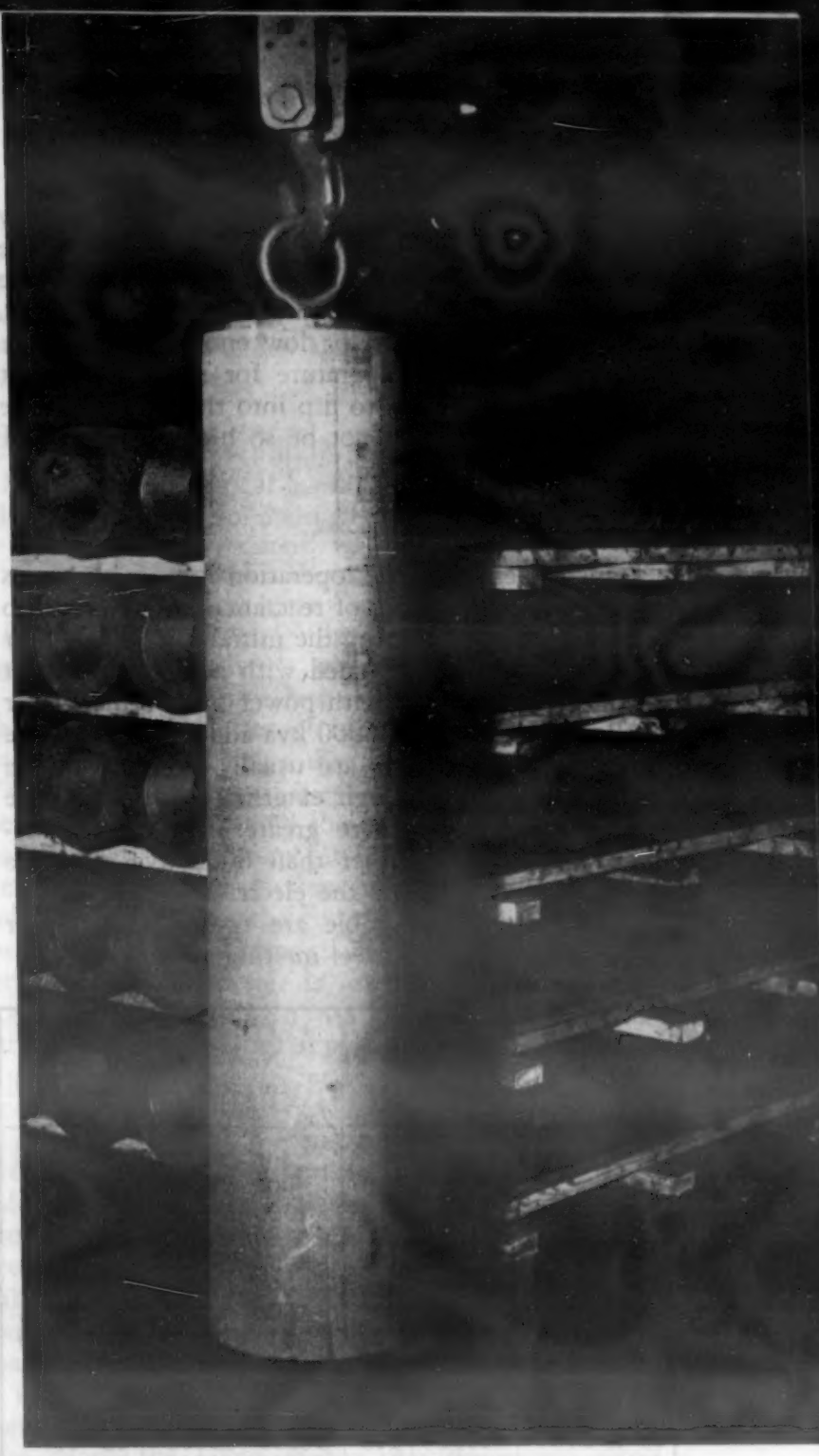
Where a charge is not compact, it is possible for the electrodes to bore through the charge to the hearth before a sufficient pool of metal is formed to prevent direct arcing on the hearth, with a possible hole resulting.

In foundry operations where a large percentage of shop scrap is returned to the furnace, adhering sand and slag may make contact difficult and result in electrode breakage. Where this cannot be avoided through careful charging, it is helpful to place a small quantity of coke or other carbonaceous material directly under the electrode involved.

As charging operations differ from plant to plant, and from one operation to another, there is no single and all inclusive safeguard that may be suggested. Acid and basic carbon steel castings, manganese steel castings, chromium-nickel castings, basic ingots, and in a few cases acid ingots, will influence the method of charging but the salient points outlined will do much to secure the best results in furnace operation and electrode service.

Electrical Conditions

Electricity and the equipment to control it for the purpose of producing steel form the heart of an electric furnace installation. It follows that the proper use of electricity for the melting and refining of steel



Electrodes are moved from storage pile to furnace by screwing in steel lifting plug and transporting by overhead crane.

is of paramount importance. The proper use of electricity, in turn, is based upon the capacities and requirements of furnaces and electrodes to accomplish the desired melting and refining process. In effect, electrical equipment must be regarded as a means of delivering current to its final destination in the electric arc. If, for example, too low a voltage is used during refining, the arc gap will shorten until the electrodes dip into and are washed by the molten bath, with a coincident high electrode consumption.

Correct voltages are determined by the capacity of the furnace, spacing of electrodes, distance of the arc from sidewalls, and the type of charge as well as the grade of steel to be produced. As a general rule a lower voltage and higher reactance are used during the first few minutes of the melt-down, to minimize current surges and the violent shocks that would be sustained from these by electrodes were higher voltages used at the outset. As the arcs are stabilized, the voltage is increased to the desired maximum.

With the progress of the melt, the heat receptivity of the metal decreases with increase in temperature so that the power input should be decreased in one or more steps by lowering the voltage and current. The final voltage should be low enough to hold the heat at a constant temperature for refining without allowing the electrodes to dip into the bath. But the refining voltage should not be so high that the roof and side walls are burned.

Transformers

Transformers for the operation of arc furnaces require a certain amount of reactance in the circuit to limit current surges during the initial melt-down. For this reason they are designed with a higher inherent reactance than is usual with power transformers. For installation of less than 6000 kva additional reactance is required and reactors are usually installed in the transformer tank, although external reactors may be used in some cases where greater flexibility is desired. With power higher than 6000 kva adequate reactance is provided by the electrical circuit.

Summarized in the table are typical transformer ratings for the modern steel melting furnaces:

Nominal Shell Diam.	*Transformer Rating, kva*	*Normal Chg. Lb.*	*Electrode Size (Graphite), in.*
3'6"	200 - 250	400 - 500	2½ or 3
4'0"	250 - 350	800 - 1000	3
4'6" to 4'9"	350 - 500	1500 - 2000	3 - 4
5'0"	500 - 750	3500 - 4000	4
6'0"	750 - 1000	4000 - 5000	5⅛
7'0" to 7'3"	1200 - 1500	5000 - 7000	6
8'0"	1500 - 2000	6000 - 9000	7 - 8
8'6" to 9'	2000 - 3000	7000 - 12000	8 - 9 - 10
10'0"	2500 - 3500	16000 - 20000	10 - 12
11'0"	4000 - 5000	20000 - 25000	14
12'0"	6000 - 7500	30000 - 40000	14
13' to 14'	6000 - 7500	50000 - 55000	16 - 17
15' to 16'	10000	60000 - 80000	17 - 18
17'0"	10000 - 12000	90000 - 100000	18 - 20
18'0"	12000 - 15000	110000 - 140000	18 - 20
19'0"	12000 - 15000	140000 - 150000	18 - 20
20'0"	12000 - 15000	160000 - 180000	20

Regulators

To avoid electrode breakage, carbon pick up from the electrodes dipping in the molten bath, and to obtain equal heat distribution for uniform melting, the automatic electrode control system and the winch motors must be in perfect working condition. Also, cables supporting the gallows arms should not bind at any point.

Today the most generally used type of automatic electrode regulator is one which is controlled by both the current flowing in the electrode circuit and voltage drop across the electrode arc. In this manner a constant predetermined power input is maintained which can be varied at will by suitable rheostats in the automatic control circuit mounted on the control panel. The electrodes are usually raised and lowered by reversing motors working through a winch and

The electrodes move with the furnace as it is tilted to tap a 100-ton heat. (Courtesy: Timken Roller Bearing Co.)

cable arrangement. Independent movement of the electrodes is controlled by a manually operated switch.

Regulators should be so adjusted that the current in amperes is the same on all three phases. Maladjustment of regulators can be readily determined by unequal ammeter readings in the different phases.

A perfect ground from the furnace shell to the regulator is essential. A "current voltage" regulator will not work without a perfect ground, and, at times, the regulator will not work when starting up on a cold furnace. The reason for this is that the scrap charge, when cold, is not effectively grounded through the furnace bottom to the furnace shell. This condition more often obtains with an acid than with a basic bottom due to the lower conductivity of the acid refractories. It can be corrected by grounding the scrap metal charge to the furnace shell with an iron bar until such time as the charge becomes grounded to the shell.

Electrical Characteristics

The curves, Fig. 2, embody the electrical characteristics of a typical steel melting arc furnace, from which it will be observed there is a maximum power that can be supplied by any electrical system. This maximum power always occurs at 0.707 power factor.

The difference between the curves "KW in arc" and "KW in circuit" represents the losses in the system. The maximum "KW in arc" occurs at some power factor greater than 0.707 depending upon the constants of the circuit. For a furnace with given values of reactance and voltage this "optimum power factor" is a fixed value. Furnace transformers are so

designed that this "optimum power factor" occurs at a reasonable value of power input, when the requisite voltage and reactance are used. A decrease in reactance or an increase of the applied voltage will increase the maximum power that can be applied to the circuit. The importance of the curves in Fig. 2 lies in illustrating the fact that, for the most efficient melting, suitable current, voltage and reactance must be chosen so that the "power factor" of "KW in the arc" does not exceed the optimum indicated.

Thermal Factors

Thermal conductivity, exposed area, volume of scrap, and temperature difference between heating medium and the charge are the primary factors governing the rate at which heat can be applied to a charge of cold scrap. All but the temperature difference between medium and charge are constant.

The temperature difference is a variable dependent upon the heating method and the temperature of the charge. Although this is true, there is a limit to the temperature difference that can obtain, which in turn limits the rate of heat absorption. This means that temperature difference is a determinable variable. When so determined, the maximum rate of heat absorption, or heat receptivity of the charge, is a fixed value that may be translated into the desired optimum power input.

The optimum power input is around 360 kw per ton of scrap charged, during the initial stages of melting and when the charge as a whole is relatively cool. The heat receptivity of the charge decreases as the melting proceeds, hence power input should be cut down.

It is important to note that when the scrap is large and carelessly charged, the heat receptivity of the charge is lowered. Many furnaces are operated at excessive power input with consequent increase in power, electrode and refractory consumption. Attention to optimum power input and care in the method of charging will be reflected in lower power and electrode consumption and will obtain longer life from the roof and side wall refractories.

Excessive Oxidation

Electrodes are composed entirely of carbonaceous materials, and as such, they conform to the laws of oxidation. Oxidation of electrodes takes place only when the electrodes are extremely hot and exposed to the air. To control oxidation during furnace shut down periods, raise the electrodes as high out of the furnace as possible and lute up the clearance between electrode glands and electrodes with fire clay. This shuts off the hot air from the furnace and speeds the cooling of the electrodes.

Disproportionate amounts of highly oxidized or rusty scrap in the furnace charge will cause excessive oxidization of the electrodes. Often joints will become so weakened from this that they are unable to withstand the normal hazards of breakage from the charge.

If electrode joints are found to "wasp," indicated by a noticeable reduction in the diameter of the joint section and by a heightened intensity of color in the same area, the cause is usually loose or improperly made joints. Poor electrical contact and increased resistance cause the overheating and its corollary of faster oxidation. Tighten the joint and the trouble will usually disappear.

Mechanical Breakage During Use

Nearly all mechanical breakage is directly attributable to one of the following:

1. Loose gallows arms.
2. Off center roof and cooling rings.
3. Poor electrical contact with charge.

Loose Gallows Arms: Vibration due to the binding of worn crossheads connecting gallows arms to masts, and excessive lateral play of gallows arms are two primary causes of loosened joints and consequent nipple breakage during furnace operations. Where either or both of these conditions are present, the surges of current and the frequent movement by the automatic regulators produce constant shock in the form of a vertical vibration from the regulation and a side slap from the current surges. Periodic inspections and adjustments should be made. In making necessary adjustments it is important that the electrode holders be lined up in a vertical plane throughout the entire length of travel. Some lateral motion is necessary as a cushion for the thrusts the electrodes receive during the melt-down, but this should not be so great as to permit the electrodes to slap about.

Off Center Roof and Cooling Rings: Electrode holders should be vertical regardless of their position above the roof. They should be centered precisely over roof openings, as binding in the cooling rings will produce breakage. This presumes that roof and cooling rings will first have been centered. A great deal of electrode breakage is mistakenly attributed to off center holders when the cause lies in misalignment of the roof. Whenever a roof is changed, great care should be taken to see that the new roof is placed in exact position.

Poor Electrical Contact with Charge: Charging a furnace with large quantities of low grade scrap insulated with dirt, rust, and sand often causes mechanical electrode breakage during the initial melt-down period. The insulation on the scrap prevents proper electrical contact and the electrodes fail to arc. The automatic regulators continue to feed and the weight of the electrode columns and gallows arms comes down on the charge to produce an end thrust on the electrodes which loosens and weakens the joints.

This leads to failure. Even when the current finds a point of contact at which it can arc, the electrodes are subjected to heavy current surges until the contact is broken. This trouble can be largely avoided through observing the charging precautions enumerated earlier in this article.

The precautions and practices that have been outlined will make for the most efficient and economical use of electrodes in the production of steel. If these practices are not followed, the operator will find his production costs and troubles increasing in direct ratio to the degree which he violates them.

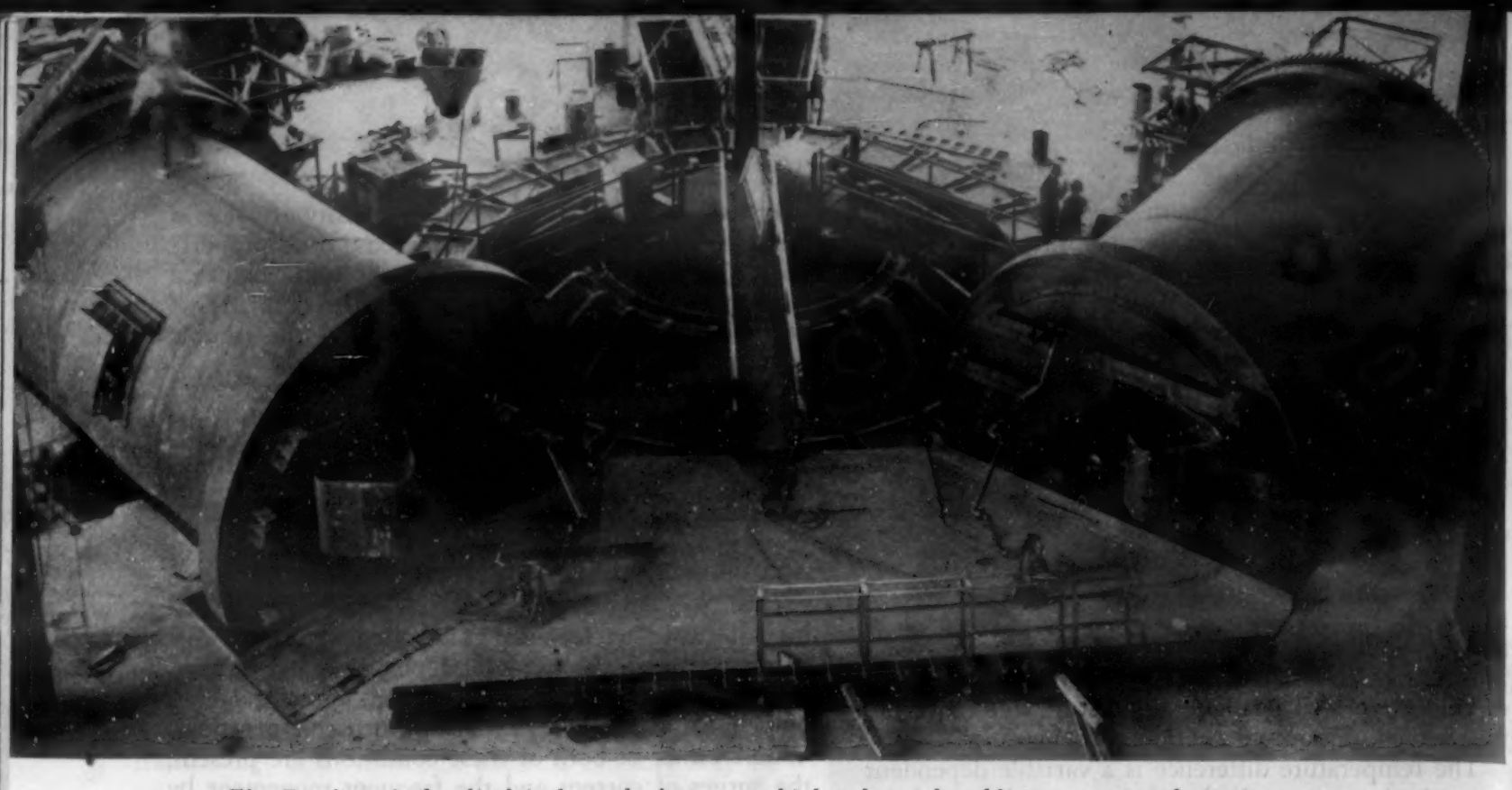


Fig. 7. A typical cylindrical anode furnace which takes a hot blister copper charge.

Basic Refractories for the Copper Industry

Part 3

by R. P. HEUER AND A. E. FITZGERALD

General Refractories Co., Philadelphia

Previous instalments of this article, in our May and June issues discussed reverberatory furnaces and converters. This concluding section is devoted chiefly to refining furnaces. —*The Editors*

Refining Furnaces—General Construction

The selection of refractories for refining furnaces involves two main considerations, namely the amount of refining which must be done and the temperature fluctuations to which the refractories will be subjected. If the operation is such that little refining is necessary but much heating and cooling of furnace refractories occur, the acid brick normally does the best job. On the other hand, if a great deal of refining is necessary and there is little temperature fluctuation, the basic brick does the best job. Generally there is sufficient refining to keep the life of the acid brick low and the objective becomes one of eliminating the acid brick and substituting the basic.

Continuous charging wherein the furnace refractories are not cooled during the charging operation has resulted in a much wider use of basic refractories. This method of charging has been applied to both molten blister and cold cathodes and is used in connection with many types of furnaces. A typical example is the cylindrical anode furnace taking a hot blister copper charge. This furnace, in general appearance, is much like a Pierce-Smith converter without tuyeres.

A typical furnace is shown in Fig. 7. This was originally built of burned magnesite brick below the metal line and silica or clay brick in the upper section. Chemically bonded magnesite brick has generally replaced both the burned magnesite and the silica or clay wherever used. One furnace lined entirely with chemically bonded magnesite ran for over 4 yr. without repairs.

Another example is the semi-cylindrical anode furnace. This differs from the cylindrical in that the top, or roof section, is flatter and not so thoroughly bound by the furnace casing. The roof section is a conventional sprung arch commonly about 11 ft. to 13 ft. in span. As in the case of the cylindrical furnace, the original construction was burned magnesite brick below the metal line and silica brick in the roof. Chemically bonded magnesite has displaced silica in the roof and the furnace is completely basic.

The same trend toward completely basic construction developed in the reverberatory type anode furnaces taking a hot blister charge. Reverberatory furnace construction prior to the use of molten blister for anodes has been described by Boggs and Anderson[13] and Bernard[14]. This construction consisted of silica brick bottom and roof and chemically bonded magnesite brick sidewalls. At Noranda

the refractories failure occurred in the silica brick bottom. The silica brick bottom was replaced with sintered monolithic magnesite. The sprung silica roof required frequent repairs. This was replaced by suspended chemically bonded magnesite brick construction similar to that used on smelting furnaces, and the furnace was completely basic. This furnace is the only one available in the plant and must operate with a minimum of delay for repairs.

The minimum of delay has been achieved by using basic refractories throughout and working out maintenance methods which can be done without shutting down. The monolithic bottom is patched as required, the sidewalls are "shot" about once a week with finely ground magnesite or converter brick bats, the suspended roof is patched as needed following the method developed for the smelting furnace. The furnace has now run for about 3 yr. with virtually no replacement of refractories.

At another plant using a hot blister charge, 20-in. silica brick in the anode furnace hood were lasting for about only 85 charges. The silica was replaced with a sprung arch of chemically bonded magnesite brick with thin metal plates in the joints and the life on these hoods increased from 85 charges to a range of 327 to 449 charges.

It will be noted that the sprung arch span is about 15 ft. This is quite large for the relatively heavy magnesite brick and the arch can become rather unstable after a very long campaign. Experience to date indicates that on such a large span and for such a long campaign a suspended basic arch, as developed for smelting furnaces, has considerable merit.

In another operation a reverberatory type furnace is charged with hot blister to produce refined copper. This furnace was originally constructed with a silica bottom and roof and magnesite sidewalls. As in the case of the anode furnaces, the silica bottom was the first to cause trouble. In this case, wear occurred in the silica brick at the junction of the silica bottom and the magnesite sidewall. This wear was sufficient to undercut the sidewall requiring renewal of both the bottom and the sidewall. In this case magnesite brick is being substituted for silica and installed as shoulders in the bottom extending several feet out from the sidewall.

Another group of refining furnaces from which silica brick has been eliminated are those which are working on continuous cathode charge. The charge is cold but continuous charging with small amounts prevents any great cooling of the furnace brickwork. Both reverberatory and electric arc furnaces having a roof span or diameter of up to 12½ ft. are in service. Chemically bonded magnesite brick are generally used in roof and sidewalls. Electric furnace roofs are reported to be practically unharmed after two years' service.

A very large percentage of the refining furnaces are at refineries located some distance from the smelter. These are reverberatory type furnaces and variously described as anode, wire-bar, merchant, fine copper, or scrap furnaces. These furnaces are charged with cold blister. scrap or cathodes. Further, they are batch charged rather than continuously charged and in certain parts of the furnace there is considerable cooling of the refractories followed by rapid heating after charging.

This fluctuating temperature tends to set up spalling in basic refractories. Consequently, these furnaces, on the whole, have not been built so completely of basic brick as have those which are charged without a great drop of temperature. However, by virtue of a better knowledge of service conditions in the various parts of the furnace and improvement in basic brick and basic brick construction, the amount of basic brick in these furnaces has been considerably increased.

Bottom Construction

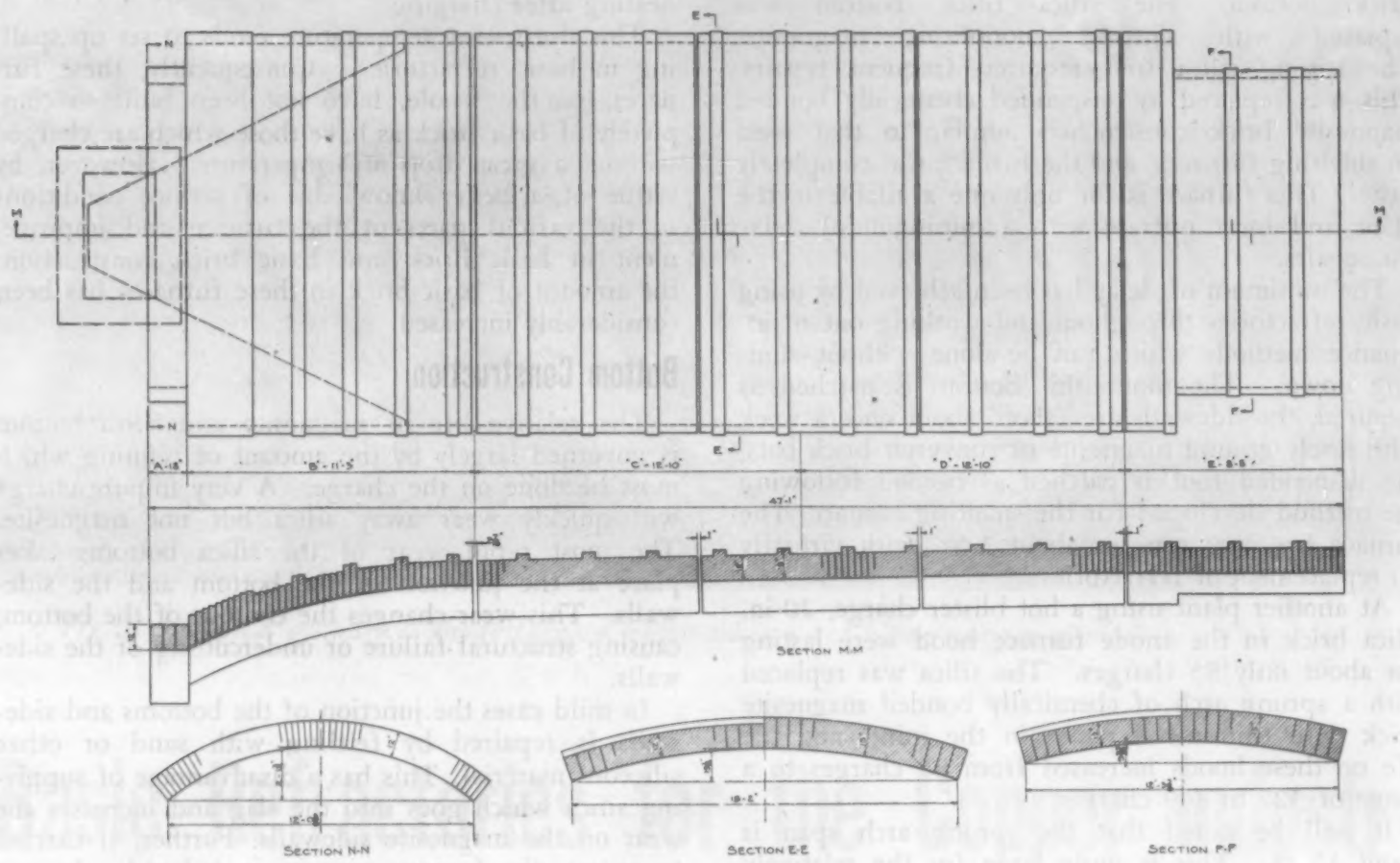
The relative life of magnesite and silica bottom is governed largely by the amount of refining which must be done on the charge. A very impure charge will quickly wear away silica but not magnesite. The most rapid wear of the silica bottoms takes place at the junction of the bottom and the sidewalls. This wear changes the contour of the bottom, causing structural failure or undercutting of the sidewalls.

In mild cases the junction of the bottoms and sidewalls is repaired by fettling with sand or other siliceous material. This has a disadvantage of supplying silica which goes into the slag and increases the wear on the magnesite sidewalls. Further, if carried to excess, the furnace capacity is reduced. In one plant, anode furnaces with 12 in. silica brick bottoms gave approximately 150 charges before repairs; 12-in. burned magnesite bottoms gave 850 charges without repairs. One magnesite bottom lasted 1,729 charges (6-yr.) with the original bottom and additional repairs equivalent to a second bottom.

In wire bar furnaces the life of silica bottoms is usually longer because of the cleaner nature of the charge. The most rapid wear occurs adjacent to the sidewalls and in the bottom area near the bridgewall. One wire bar furnace which customarily gave about 500 charges on a 12-in. silica bottom, operated with a 9-in. burned magnesite bottom from 1923 to 1941 making 3,653 charges with 20 repairs. The bottom was replaced with a 12-in burned magnesite bottom in 1941, which has run almost 3 yr. to make 661 charges without repairs. In addition to the longer life, the life before

Fig. 8. An extreme case of bulging in a furnace in which basic brick was substituted for clay or silica brick in backwalls with insufficient allowance for expansion.

Fig. 9. The introduction of basic roofs to cold charge intermittently operated furnaces has been difficult. The construction of a large scale experiment is here illustrated.



repairs is much longer than silica. It is also much easier to remove damaged brickwork and make repairs in a magnesite bottom without destroying adjoining brickwork which may be in good condition.

Experiments are also being made with monolithic magnesite bottoms. These are rammed into place cold and subsequently burned in. The experiments include repairs at the junction of the bottom and sidewalls, repairs to silica and magnesite bottoms.

For furnace sidewalls below the metal line burned magnesite and chemically bonded magnesite are customarily used for the construction of back walls or sidewalls. Above the metal line preferred practice now uses basic brick in place of silica or fireclay brick formerly used. Chemically bonded chrome-magnesite, magnesite and steel clad brick are being used. The life of the backwall is longer toward the stack end and decreases toward the bridgewall and the burners. This is due to the difference in thermal shock. The heating up after charging is more rapid near the burners and thermal shock is greater at that point. Where severe spalling conditions exist, increased life has been obtained by the use of steel clad chemically bonded magnesite brick. In the case of one anode furnace, a 12-in. backwall lasted 35 charges in the section between the tap hole and the bridgewall. Steel clad brick lasted 130 charges and their use is economical. Steel clad brick in the backwall between tap hole and nose last 300 charges. The substitution of chemically bonded chrome-magnesite for chemically bonded magnesite has been increasing. This may be due to better spalling resistance and somewhat lower costs. One objection to chrome-magnesite brick, which has been reported in some plants, is the difficulty of recovering the metal value when the worn out brick are smelted. Ways and means are being found to overcome this.

Providing for Expansion

In the construction of large basic walls, proper and sufficient provision must be made for expansion. Occasionally, in substituting basic brick for clay or silica brick in backwalls insufficient allowance is made for expansion and the basic wall bulges or buckles and shears off.

An extreme case is illustrated in Fig. 8. This wall was built of 12 x 6 x 3-in brick laid as headers and on the flat. For part of the wall the back 3 in. fitted under a steel beam. Splits and key brick were used on top of the wall to fill-in snugly the space between the top of the wall and the sprung silica roof. Bulging was noted after a short period of operation and an examination revealed the condition shown in Fig. 8. The hot face had expanded or grown, a shear line had developed 5-in. from the hot face and, with the roof and bottom acting as skewbacks, an arch was formed of the 5 in. which sheared off.

It is assumed that in heating up the furnace the roof rose enough to form an opening between the roof and walls for a distance of about 5 in. in from the hot face of the wall, while the balance of the wall remained tightly clamped down. The hotter portion of the wall was free to move, the balance was not, and the shear resulted. The trouble was subsequently avoided by leaving space over the

entire top of the wall for whatever movement might take place.

In addition to providing expansion without setting up shearing stress, the expansion allowance must be sufficient to avoid even uniformly distributed pressure of considerable magnitude. These expansion allowances must be very generous. The expansion of magnesite brick is 2.0% linear at 2400 F., while that of silica and fireclay brick is 1.3% and 0.6%, respectively.

Still greater allowances must be made if steel plates are in the joints. These steel plates, under ideal conditions will oxidize and can grow to three times their original thickness. A wall built entirely of steel clad is a good example. The plating on steel clad is 1/16 in. thick. A wall built of 12 x 6 x 3-in. brick, laid on the flat, has in each foot of height 11½ in. of magnesite brick, ½ in. metal. Theoretically these 12 in. of height at 2400 F. can become 13¼ in., equal to about 10% expansion.

Actually, some of the expansion is taken up in the joints, but there is sufficient expansion over a long period of time to warrant generous allowances. This is done by leaving plenty of room for movement. The space allowed at the top of the wall may be merely filled with ground magnesite or thin brick splits, which are removed at intervals.

Another type of growth or expansion has been observed in magnesite walls. This is due to reaction between the magnesite brick and the siliceous drip from the roof. The reaction forms a magnesia-silica compound identified, in some cases, as forsterite. Most of the trouble due to forsterite formation is eliminated by sufficient provision for expansion as described above.

A further cure for this particular trouble is the elimination of one of the two materials, magnesite and silica, taking part in the reaction. Chrome-magnesite brick have proved satisfactory in place of magnesite brick for this purpose. The other possibility is the elimination of silica brick in the roof.

Basic Roofs for Intermittent Operation

The status of basic roofs in continuously operated furnaces has already been described. The introduction of basic roofs to cold charge intermittently operated furnaces has been more difficult, but progress has been made. One large scale experiment is worthy of description. The construction is illustrated in Fig. 9. The brick shapes were chemically bonded chrome-magnesite keys 3 in. thick. These were laid in rings with 1/32 in. thick steel plates in all joints. The furnace charge was cold blister and scrap, and the fuel powdered coal. In areas E and D repairs were necessary after 115 charges. Normal life of 12-in. fireclay brick in area E and 12-in. silica brick in area D is about 50 charges.

Contrary to expectations, the rib construction did not permit small repairs. The roof brick were not sufficiently fused together to carry the great weight of the basic brick. Area C ran for 186 charges before repairs were necessary, or about five times as long as 12-in. silica. Area B, the hood, ran 285 charges, or nearly six times as long as 12-in. silica.

The difference in life of areas D and B is due to the extent to which the brick are cooled during charging and the rate of heating after charging. Area D cools more during charging, and being closer to the burners, is more rapidly heated after charging. This causes more spalling and lower life than in B. The basic hood proved economical and is in regular use at this plant, averaging about 250 charges.

The latest report advised as follows: "222 charges before any repair, and then about 25% replacement due entirely to losing shape caused by making repairs to the main silica roof." Further experiments are now under way on this particular sprung arch. In these the basic brick is being extended 6 to 8 ft. from the hood out into the area C.

It is evident from the above that where there is a minor amount of thermal shock, basic brick are more economical than acid. Further, that improvements in basic brick have extended the field for basic brick. It is also evident that considerable work remains to be done, particularly in connection with roofs in intermittent operations.

Experience to date with roofs may be summed up as follows: In roofs having a span of approximately 25 ft. basic sprung arches are unstable and unsatisfactory, even though the operation is continuous and there is little thermal shock. If the span is reduced to about 15 ft. and the operation is continuous, a life of 1½ to possibly 3 yr. can be reasonably expected. Where the operation is intermittent the life expectancy on a sprung arch hood is approximately 1 yr., with a corresponding decrease in life, as thermal shock is increased.

A sprung basic arch becomes unstable as it gets thin. This is due to the great weight of the brick and the relatively high thermal expansion. The high thermal expansion results in considerable movement with changes in temperature. Further, a sprung basic arch is difficult to repair in localized areas.

It is believed that a suspended rather than a sprung basic arch offers some possibility. If suspended, the arch does not become unstable when thin and localized areas of wear can be patched, as in the case of the smelting furnaces. This method of patching reduces the amount of brick consumed and avoids the delays experienced with sprung arch construction.

Numerous furnaces of the reverberatory type are in operation for the treatment of copper and brass and the length ranges from 10 to 20 ft., the width from 6 to 12 ft. The service on refractories is usually more severe in the copper furnace than in the brass furnace. This requires a wider use of basic brick in the copper furnaces. Bottoms and sidewalls up to the roof are built of chemically bonded magnesite brick. The bottoms are 9 or 12 in. thick and they are usually laid on a course of fireclay brick.

In certain instances, particularly where spalling is a problem, unburned chrome-magnesite or steel clad brick can be used to advantage in sidewalls above the metal line. The uptake or stack is subject to severe service where the outgoing gases strike after passing under the verb arch. Best service is obtained by building, or at least veneering, this area with unburned chrome-magnesite. The verb arch

Fig. 10. This illustrates a test where unburned magnesite brick were built with a door arch and jamb for comparison with fireclay brick.

and the hood or sloping section of the roof from the verb arch to the main roof has the longest life when built of unburned chrome-magnesite.

The roof thickness depends upon the size of the furnace and life expected. A 9-in. thickness is sufficient for a small steadily operated furnace. A 12-in. thickness provides more stability. The use of metal plates in the joints can be of advantage as demonstrated in the large copper furnaces. The section of the roof near the burners is frequently subject to severe thermal shock. If this thermal shock is too severe for basic brick 70% alumina brick, high fired or regular super duty or dense fireclay refractories may be used.

The service conditions in brass furnaces vary widely. In some instances the charge, amount of refining and temperatures make the service conditions as severe as in the copper furnaces. In general, however, the conditions are less severe than the copper furnace and the refractory construction differs slightly. At one time all bottoms were built of fireclay brick.

The best type of this construction is that which uses blocks approximately 18 x 9 x 4½ in. These are laid on end providing a bottom 18 in. thick. Care is taken in laying these bricks so that open or large joints are kept to a minimum. These clay brick bottoms are ultimately worn out from contact with basic oxide and slag. In some instances longer life has been obtained by substituting the high fired super duty clay brick for the fireclay brick.

The best life, however, is obtained by the use of basic brick and basic brick bottoms are now in common use. The construction of the bottoms is similar to that described for the copper furnace. At least eight such bottoms are now built of chemically bonded magnesite brick. One 9-in. thick bottom has been in operation for over 4 yr. without repairs.

The sidewalls from the bottoms to a point just above the slag line are now commonly built of basic brick. These basic walls are usually 9 to 13½ in. thick, backed up by 4½ to 9 in. of clay brick. Above the slag line the basic sidewalls are frequently 4½ to 9 in. thinner than below the slag line.

In some cases the basic wall is only 4½ in. thick veneer. This is often unsatisfactory. Such a wall is likely to be unstable. It is better if a minimum of 9 in. of basic brick is used. The brick in the sidewalls above the slag line are usually subject to greater thermal shock than in the sidewalls below the slag line or in the bottom. This is particularly true when charging is so rapid and on such a scale that there is a big temperature drop in the unprotected portions of the furnace.

If spalling conditions are not excessive basic brick are recommended for upper sidewalls. Fig. 10 illustrates a test where unburned magnesite brick were built into a door arch and jamb for comparison with fireclay brick. The photograph was taken after three months service. The fireclay brick are worn back from 6 to 9 in. and the unburned magnesite brick are practically unaffected. Even the fireclay brick which were tied in to the basic brick along the door jamb have melted out without affecting the surrounding basic brick.

In some instances considerable spalling may be encountered in magnesite brick. In such cases the substitution of unburned chrome-magnesite or steel clad brick for the magnesite provides additional resistance to spalling.

In those cases where thermal shock is found to be too severe for any kind of basic brick, several types of refractories are in use. One is a new type of 70% alumina brick of low porosity. This brick is now in use in several furnaces with very satisfactory results. Super duty clay brick, both high fired and regular grades, and dense high duty fire clay brick of low porosity and high resistance to spalling are widely used where spalling conditions are very severe. As in the case of copper furnaces rapid wear frequently occurs in the uptakes. In one case super duty brick lasted twice as long as clay brick; in another unburned chrome-magnesite lasted three times as long as super duty.

The use of the basic brick has been proposed for the hood and main roof. Progress along this line has been admittedly slow and for the following reasons. A sprung arch built of basic brick requires more careful attention than one of non-basic brick. The life of non-basic brick in brass furnaces is often relatively good, thus requiring very long service from the basic if the latter is to be economical. Reports indicate the life of non-basic roofs varying from 40 to as much as 160 days.

In one case, at least, unburned chrome-magnesite brick are now regularly used for hood construction. Several other trials are in progress. The main roof is usually subject to more thermal shock than the hood.

The trend in roof construction has been toward roofs that are thicker and the use of more expensive refractories. In some instances the roof thickness has been increased from 9 to 12 or 13½ in. In other instances the clay brick has been displaced by super duty. The super duty has also been displaced by high fired super duty. As yet the special 70% alumina brick has not been tried but its performance in upper sidewalls indicates this will be done. One roof of basic brick has just been put in service. The logical outcome of the trend is the use of a basic brick.

Here is an extremely powerful unit, a bull-block for making a single reduction on very heavy steel rod. Both plain carbon and alloy steel wire for fabrication of heavy bolts and rivets are drawn here.

Modern Wire Drawing Practice

A Pictorial Trip through a New Mill

WIRE DRAWING is a fairly ancient art and an art that requires skill in full measure. In many communities of the world wire makers pass down from father to son the various twists of the wrists and brain kinks that are translated into wire making "know how." Such a community is Worcester, Mass. where the Washburn and Moen works turned out some of the first wire made, mass production, in this country. They brought from Sweden many skilled artisans. Their grandsons and great grandsons form the nucleus of the skilled working force in the New South Works mill of the American Steel & Wire Co., that city.

The new mill is a vast housing where working space is ample, comfort is all that could be reasonably expected, with plenty of aisle space, muscle-saving devices and efficiency generally.

Any member of an ancient wire making family, upon going through the new South Works, would realize that there have been no radical changes in wire making over the past generation, though would find plenty that is new and novel. Tungsten carbide dies, for instance, are an application of the past ten years, diamonds being used only for the smaller gages. In this mill the conventional, but somewhat awkward wire "buggy" would be found absent and instead some newly designed trucks which bustle about, transporting coils from one department to another.

One of the first questions that an amateur would ask is: "Why are razor blade strips made in a wire mill?" An old-timer would reply: "In the early days came a request for flat wire. Round wire was flattened in small rolling mills and that was the beginning of strip manufacture."

Among innovations are a slanting heat-treating furnace, the strips passing through by gravity, the purpose being to avoid marring the steel; a storage rack for wire rods at the receiving end of the plant, made of structural steel, the idea being copied in other plants.

So, let's start out on our trip through the mill. We may not follow a logical sequence in our inspection—say, from raw material to finished product—but we will take in important points of interest. —H.A.K.

This automatic conveyor transfers rods from the railroad car or rod storage building to the cleaning department, immediately adjacent. It is being picked up by an overhead crane for immersion in an acid bath.

Certain medium carbon steel coming into the mill is placed in a normalizing furnace which removes internal stresses and imparts certain desirable physical characteristics. Temperatures are controlled automatically, with treatment lasting 41½ hr.

This double-lead patenting furnace governs the grain structure of high carbon steel rods or wire and gives wanted characteristics for future drawing. Here the work is preheated in an oil-fired chamber, then immersed in two molten lead baths, the first at 1640 F. and the second at 975 F. As the rods emerge from the hotter lead bath into the colder bath, they pass through granulated coal to prevent oxidation. The operator is adding a pig of lead to the bath.

This is the exit end of the heating zone of t patenting furnace. High grade high carbon wir such as for aircraft, are drawn from the rod treat in this unit. Subjected to 1650 F., then quenched, t rod acquires extreme toughness. Here the mater is entering the lead quench before going upon t take-up reels.

This operator works a single draft drawing m chine. The wire is paid off a reel at the left, passi through the die in the small box-like holder a thence onto the take-up block at the right. Here t workman has stopped the block and is checking t wire diameter with a "mike" as it leaves the die bo

The vats might suggest a brewery—but not here, friend. This is a general view of the wet wire drawing room cleaning and coating house. Here wires to be drawn on wet machines are immersed in an acid bath to remove scale and rust. They are then coated with tin or copper by chemical deposition, followed by a dip in lime and a hot air dry.

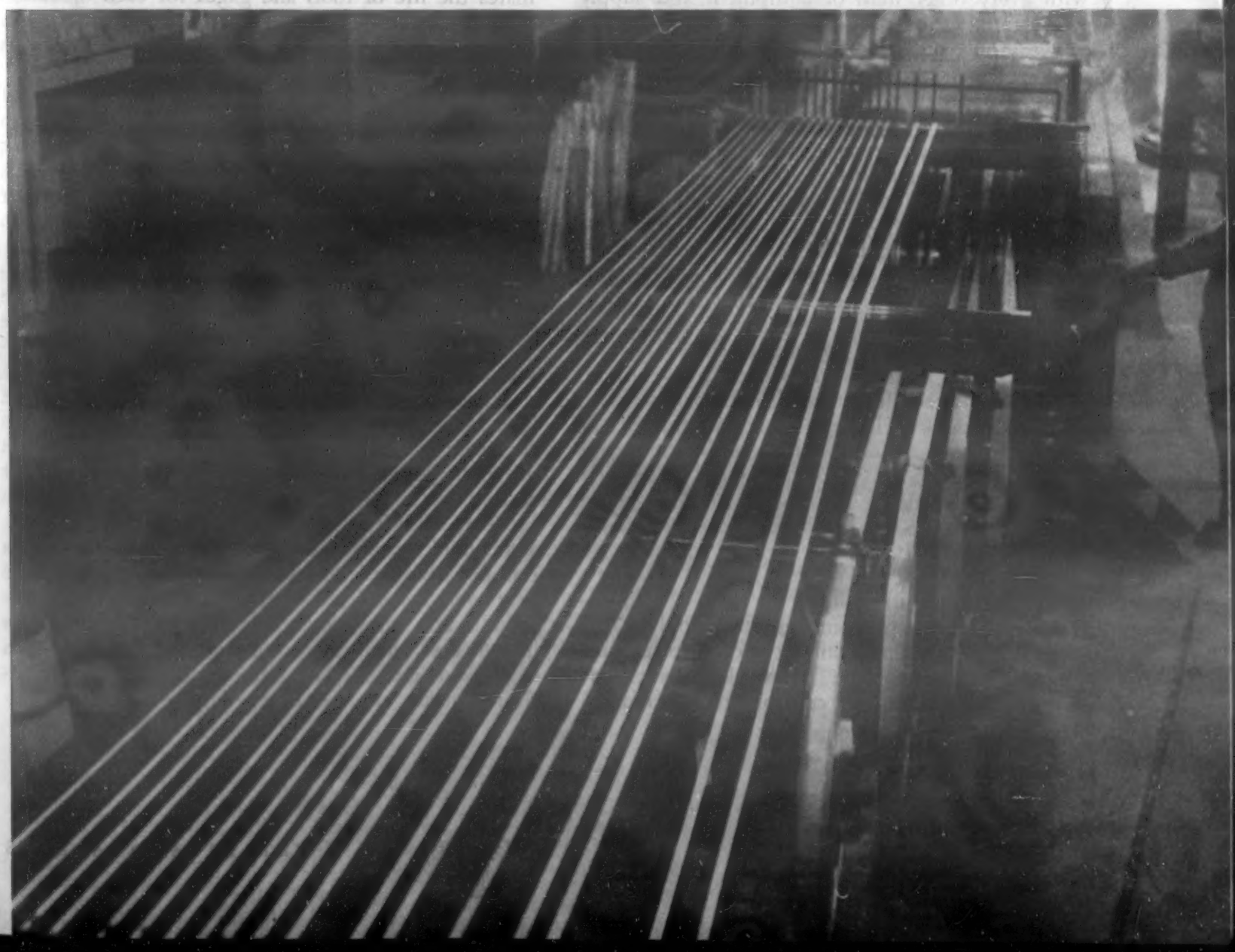
These syncro wire drawers make from 7 to 14 continuous drafts. As the wire passes through each successive die, mounted in the center arm, it is elongated, making necessary the graduating increase in the size of the drums over which the new wire passes. The milk-like, soapy, liquid lubricates and dissipates heat. Such fine wires are used as card wire for the textile industry, for stapling, basket weave armoring and army field telephones.

As we came into this die servicing room we remarked to the plant superintendent, acting as guide: "These must be the most highly skilled workmen of all." He stepped on our foot and whispered: "Not so loud—yes, but we mustn't tell them that." Here the tungsten-carbide dies are serviced to provide a perfect contour for re-use.

At the single-pan galvanizing unit a zinc coating is given to intermediate sizes of wire for the Navy. Wire passes through the molten zinc, a set of wipers and a water rinse before passing on to the take-up reels.

Tinning and galvanizing fine wire is an apparently attractive operation. In this case ten wires are leaving the bath of molten metal in the foreground and are passing through a water rinse before going upon the take-up blocks in the background.

Four different widths of strip steel are here receiving a zinc coating simultaneously in the electro-galvanizing department. This unit anneals, cleans and coats the material in one continuous operation. The strip is shown here prior to going onto the take-up blocks.



Silver Brazing of Tools and Gages

by FREDERIC L. WOODCOCK

Chief Tool Engineer, Hamilton Standard Propellers Div., United Aircraft, East Hartford, Conn.

Applied heavily in wartime for conservation reasons, silver alloy brazing has demonstrated its utility on a strictly economic basis and is destined for continuing use in post-war production. It has been broadly employed for the repair and rehabilitation of broken and worn tools, dies and gages and for the construction of new tipped tools. This practical article discusses applications of both types and gives details of operating technique. —*The Editors*

Fluxing a cracked saw. The operator spreads the paste uniformly and into the crack itself, using a brush. When the flux becomes entirely fluid, the temperature has reached 1100 F. A few seconds later the temperature will be 1175 F. and the low temperature silver brazing alloy may be applied.

TOOLS AND GAGES have one property in common with every other item of equipment and supply for manufacturing purposes. Their life is limited. They wear out, suffer breakage and end up in the scrap barrel as is the way of many material things.

While this progression is usually accepted as inevitable, it is more serious in tools and gages than in many other manufacturing accessories. They are expensive, take labor to make, and what is most important under pressure of war needs, take long weeks for delivery.

So, as in few other fields, conservation and reclamation of tools and gages have assumed an importance far beyond any previous consideration. As is usually the case when a need makes itself felt, a solution to the problem is found. A large proportion of all broken or worn-out tools and gages can be reclaimed and their life extended by simple and economical methods. They can be reconditioned and restored physically to their original appearance and usefulness. Tools can also be designed to provide for a more extended life in service through simple regrinding operations.

A Tool Conservation System

A tool reclamation program rests upon only a few basic principles. Fundamentally, it is centered around the tool engineer or manager. He works between engineering and production, controls tool grinding, handles broken or worn-out tools and gages, estimates the life of tools and gages for each operation and he maintains tool performance records. His most valuable contribution to the organization is the reduction of downtime on machines.

The tool manager must have the cooperation of the metallurgist, the tool designer, the production engineer, the welding engineer, the factory manager and the set-up operators. In large companies this work calls for a separate department, but in smaller organizations it can be handled by the production department.

First and foremost the tool manager must maintain accurate records of tool performance and gage life. If tools break too frequently or gages must be replaced too often, the specifications should be reviewed in detail and the causes analyzed.

Secondly, he should keep tool drawings up to date. The latest changes in design or dimensions resulting from latest shop experience must be recorded on all tool and gage drawings as soon as accepted or proved.

When additional tools are required, the tool manager should check his discarded tools to see which can be salvaged and use the salvaged tools before new tools are ordered or released.

In a few cases, tools can only be salvaged at a higher cost than the originals. But in these days of slow deliveries, the saving of downtime on machines makes the extra expenditure advisable. Al-

most always, however, the cost of salvage is far below the cost of a new tool, and generally only a fraction of it.

A good procedure to follow in the tool department is to set up a storage system for discarded tools or gages and to draw on these discards for rough blanks to re-work in an emergency. After a number of a single kind have accumulated, a full lot can be processed into usable tools at low cost.

By far the major part of a tool reclamation program is the repair of broken tools and the rehabilitation of worn-out tools. The important question involved in such work is the method of repair or reconditioning.

Various methods are available—brazing, welding, hard chromium plating, metallizing, etc.—and their relative advantages have been the subject of many discussions. No broad rules can be laid down. Each job must be judged individually. Each method has its merits, and the applications depend upon the judgment of the designer as well as the equipment available and the skill of the tool room personnel.

In many instances it will be found that the simplest, least expensive and most satisfactory method is brazing. This article will be confined to the technique and results of that method.

The Brazing Medium

Among the outstanding brazing mediums in use at present are the low temperature silver brazing alloys. Alloys of this type produce joints that are exceptionally high in strength.

The advantages of low temperature silver brazing are briefly as follows:

1. A very low working temperature or flow point can be obtained (1175 F. with Easy-Flo, a silver-cadmium-zinc-copper alloy, for example). This means short heating time and a minimum of distortion and reduction of hardness of the tool. This reduction seldom amounts to more than 1 to 3 points on the Rockwell C scale which does not lower the effectiveness of the tool, thereby saving the need of rehardening.
2. At this temperature the alloy is extremely free flowing and capillary action carries it into every part of a joint area. It can be used with minimum joint clearances, in fact the thinner the film the stronger the joint.

Applications in Tool Repair

Examples of tools that are being repaired regularly in many plants by the use of low-temperature silver brazing alloys are band saws, drills and taps, broaches, milling cutters, forming tools, metal slitting saws and gages of all types.

Broken shanks on drills, adapters or reamers are easily repaired by brazing. The broken portion is squared off, the stub is turned or ground to size and a hollow blank shank is brazed onto the stub. After brazing, the repaired shank can be turned, milled and ground to the required size. Broken tangs are easily repaired by milling a step under the break and brazing in a stepped extension; then centering, turning and grinding to the repaired form.

All sorts of tools can be reclaimed for productive use by low temperature silver brazing, thereby saving not only the expense of a new tool, but more important just now, putting back the tool into productive use within a few hours, instead of waiting days or weeks for a new one.

In general, low temperature silver brazing, as a method, produces strong, permanent joints, quickly and easily, at low cost. Silver brazing alloys are recommended also because the low melting point facilitates both the joining and the salvaging of the tip and shank. In salvaging, to separate the tips from the shanks in broken tools, the heat may be applied in any convenient manner. The tip may be removed with pliers when the brazing alloy melts. Cast alloy or carbide tips will not lose their hardness, although the temper of high speed steel tips may be slightly affected as described in repairing a broken cutter. The loss in hardness seldom exceeds 1 point on the Rockwell "C" scale.

Cemented carbide tips adapt themselves to reworking in a variety of ways, through the aid of silver brazing. For example, a discarded reamer can be ground to triangular shape, have a formed tip of cemented carbide brazed to each flat of the triangle, then be ground cylindrically to the required size, and finally the flutes are ground from the solid carbide. Care must be used to space the flutes so that the seams of the carbide strips will occur at the bottom of the flutes and not in the "lands" between.

Brazing cemented carbide, however, calls for the use of a different silver alloy, from the type used for

Proper cleaning is one of the most important steps in good brazing. A surface entirely free of oil, grease, dirt and oxides will permit the alloy to set and flow completely over the paint area. A dirty surface will result in spotty coverage and a weak braze.

GRIND END, leaving triangular shape with length of available tips.
BRAZE A FORMED TIP on each flat of triangle.
GRIND CYLINDRICALLY TO REQUIRED SIZE.
FLUTE GRIND as from solid carbide using care to register the joints in the spaces as at "X".
X

Reworking a small discarded reamer.

high speed steel. For example, Easy-Flo, which flows freely at 1175 F. is recommended for high speed steel, while Easy-Flo No. 3, which flows freely at 1270 F. provides a better wetting action and should be used for brazing cemented carbides.

Technique for Repairing Broken Tools

A variety of methods for holding the work are available, such as wiring or binding together with nickel-chromium or similar high melting point alloy wire; clamping in a vise, or in a lathe between centers; clamping on a drill press; placing in V blocks, etc. The size and shape of the tool or part to be placed will determine the type of holding fixture. Careful alignment is necessary, but it is generally not too difficult because the jagged breaks align themselves when properly matched. No two breaks or failures are alike; consequently no two repair jobs are identical. Holding fixtures may be worked out easily to suit each job according to the operator's ingenuity.

In brazing broken tools, two primary steps are involved:

1. *Preparing the parts for brazing:* Cleaning the surfaces of the joints, fluxing, pre-placing the brazing alloy, and setting up a jig or holding mechanism as required.
2. *Applying heat* by gas torch in a muffle furnace, dipping in a molten salt bath, or by induction.

An axiom in brazing practice is that the surfaces to be joined must be absolutely clean and free from oil, grease, dirt and oxides. The cleaning can be done in a variety of ways: Mechanically, by using abrasive cloth, filing, grinding, etc.; chemically, with cleaners of the chlorinated hydrocarbon type such as carbon tetrachloride or a combination of both.

Joint surfaces of broken tools are easily cleaned mechanically because they are easily reached. Cracked tools, however, offer more difficulty and usually require chemical cleaning.

Proper fluxing is essential to a good brazing operation. It keeps the brazed area clean, dissolving the oxides which build up during the heating operation. Flux also reduces the surface tension of the silver brazing alloy, enabling it to flow freely and to penetrate all parts of the joint.

The flux should melt at a temperature notably below the melting point of the brazing alloy. For example, the low temperature silver brazing alloy is best served by a flux known as "Handy Flux," which begins to melt at 800 F. and is entirely liquid, dissolving all oxides at 1100 F. The appearance of the flux acts as a guide to the temperature, showing, when fluid, that the work is at 1100 F. It is readily soluble in hot water and the excess, after brazing, is easily removable.

The flux also has been used as a substitute for carbon tetrachloride in cleaning broken tool surfaces. It is warmed to about 150 F. and applied to the broken surface with a clean rag. The tool is then wiped with a clean rag and all flux used as a cleaner removed. Then another coating of flux is applied with a brush before the tool is assembled and brazed.

There are three basic methods of repairing broken tools by brazing:

1. Feeding the silver brazing alloy by hand, in the form of wire.
2. "Pre-placing" sheet or strip of the alloy between the parts to be brazed.
3. "Pre-tinning" the joint surfaces with the silver alloy.

For small tools or small joint areas, feeding the wire is satisfactory. The parts can be fluxed and clamped in place; then wire or strip put on the top of the joint. Large tools call for "pre-placing" the brazing alloy or "pre-tinning" the broken surfaces, the object being to have the silver alloy reach every part of the joint area as quickly as possible without excessive heating.

Pre-placing has the advantage of relieving the operator of the necessity of feeding the alloy and permitting him to give full attention to his heating operation, the tool and the gas torch. For pre-placed strip various gages can be used, but 0.003-in. has been found best in most cases. The thinnest practical gage is preferable as it readily conforms to the contour of the broken surfaces when the parts are clamped together. Provision must be made for applying pressure to bring the parts together.

Before (left) and after (right) repairing a circular form tool by low temperature silver alloy brazing.

Heating Methods

Any standard type of heating may be used successfully: Gas torch, muffle furnace, dipping in a molten salt bath, or induction heating.

The oxyacetylene torch has been found best for torch heating because of its speedy action and flexibility. The best technique for this heating method is as follows:

1. Set the torch for a neutral to reducing flame.
2. Keep the torch moving to avoid hot spots and to heat the work uniformly.
3. Bring the joint and the surrounding metal to the proper temperature before applying the silver brazing alloy.
4. Apply the alloy as follows: Watch the flux; when it turns to a clear, thin fluid, the temperature is close to the flow-point of the alloy. Continue heating. Also dip the brazing alloy in flux and touch it to the joint as heating progresses. When the alloy melts and flows freely, joint members are at the proper temperature. The color at this point will be a dull red. Then reflux the brazing alloy and apply it to the joint. As the alloy is applied, keep the flame moving back and forth along the joint. This is done to maintain a uniform temperature and cause the alloy to penetrate throughout the joint area.

Where the silver brazing alloy is pre-placed, the heating technique is similar but the operation is simpler. It is only necessary to keep the flame moving over the joint and the surrounding areas until the brazing alloy has melted completely.

In "pre-tinning," the same procedures already described are used for cleaning, fluxing and heating. In torch heating, a little of the alloy is flowed onto each of the broken surfaces, puddling the molten alloy with a metal rod until both surfaces are completely wet and covered, and a uniform film is obtained. The joint is then re-fluxed, and assembled and the braze is made as if the brazing alloy had been pre-placed.

Furnace heating (oil, gas or electric) is highly satisfactory for air-hardening types of steel or carbides, giving uniform heating and accurate temperature control. The broken tool surfaces are prepared in the manner described above and the broken surfaces either pre-tinned or the brazing alloy pre-placed. The furnace temperature is set at about 1500 F. to bring the tools in the furnace up to brazing temperature rapidly. The important point is to time the heating so that the tools are taken out of the furnace immediately when the alloy becomes free-flowing, in order to avoid softening the high speed steels.

Immersion heating or dipping in molten salt mixtures has the advantages of rapidity, good control, uniformity of heating and protection from atmospheric oxidation. It is particularly useful for volume work. The methods involved are the same as for furnace heating, with the parts either pre-tinned or with the alloy pre-placed.

Induction heating offers several advantages especially for parts of uniform shape and thickness, because of its rapidity, the automatic heat control and the localized heating close to the joint. The methods of preparation are the same as for other forms of heating, namely, cleaning, fluxing and "pre-tinning" or pre-placing the alloy.

In any case, care must always be exercised to keep the heating period as short as possible. Under any type of heating method, it is vital that the brazed tools be left undisturbed until they have cooled sufficiently for the brazing alloy to set—a matter of only a few minutes.

Economies in Making New Tools

Tools and gages which have been correctly designed are likely to have a long life. Moreover, when worn out, they are more easily reclaimable because of their soundness in design. They should be simple, made up of the fewest possible number of plain, easily replaceable parts.

The assembling of tools has been greatly facilitated by the development and improvement of brazing and welding methods which have greatly reduced the need for forged solid tools. The dampening effect of the bonding material and the greater resiliency of the supporting metal give markedly longer life between grinds to tipped high speed steel tools than to solid tools.

Cutting tools today need not be made of solid high speed steel. They may consist of standardized blanks of low cost materials for the body, holder and shank, such as cast or medium carbon steel, with the cutting medium, carbide or high speed tips,

brazed into place. This type of construction makes it possible to replace the part which takes almost all of the wear—the cutting tip—whenever it is worn past economical usefulness.

There is no need to scrap the whole tool which may cost $10, $20 or even $50. It is merely necessary to remove the used tips by methods outlined below, and to replace them with new ones at very low cost. This will sometimes make the tool available for work in an hour or two, instead of waiting weeks for a new tool. The total life of such a tool, including periodic replacements of the cutting tip, is frequently many times the life of a solid tool.

Properly designed, the shank or body of the tool will have a strong cross-section. The proper seating of the cutting tip is highly important so that it will be kept in compression while the tool is operating.

In general, it may be said that tools are easily assembled by brazing with silver alloys and the finished tools are fully as strong as solid tools, if the design includes a strong body or shank; a good mechanical seat for the tip; the correct cutting medium; the correct rake angles; and correct clearance angles. Cutting tips may even be made of scrap: Pieces of high speed steel, or cast alloy cutting material, or carbide. It is, therefore, now common practice to mount the cutting tips of high speed steel and cemented tungsten carbide on tool shanks by the use of low temperature silver brazing alloys.

Tools may be made up quickly and easily in this fashion regardless of the material used for the cutting tips: High speed steel for strength and toughness; sintered carbide for hardness and wear resistance; or cast alloys for intermediate properties. Even stub ends or re-forged damaged tools can be used for high speed steel cutting tips. They can be silver brazed to any suitable body holder or shank without affecting the hardness of the tip. The operations are simple, as shown by the following example of a method for tipping a lathe tool:

1. Select the right size of tip.
2. Mill or grind the flat recess so that the tip overhangs slightly.
3. Thoroughly clean both tip and recess with carbon tetrachloride.
4. Set the shank in a vise or other holder.
5. Cover the tip and the recess with a proper flux.
6. Lay a thin shim of silver brazing alloy in the recess and also along all joints. The melting point of the alloy must not exceed 1175 F.
7. Place the tip in its proper position.
8. Heat the shank under the tip with an oxy-acetylene torch, using a neutral or slightly reducing flame.
9. When the silver brazing alloy is completely melted, press the tip firmly in place and hold until the alloy has set.
10. Immediately quench in oil to reduce the danger of drawing the hardness of the tip.
11. Grind and sharpen like any tool.

The brazing of cast alloy tips and sintered carbide tips is carried on in the same fashion as with high speed steel tips, except that oil quenching is omitted.

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Repairing a gear and a large broken drill by torch brazing with silver alloy at the Midwest Brazing & Engineering Co., Detroit.

A general view of the Kirksite die shop at North American Aviation's Kansas Division. A Kirksite furnace is shown in left foreground, with molds in the background. Some are already poured and are cooling.

Making Zinc Alloy Aircraft Forming Dies

by GERALD E. STEDMAN

As a method of speeding the preparatory and tooling phases of aircraft sheet metal forming and of improving the efficiency and economy of relatively short-run production of blanked, formed or drawn parts, the use of zinc alloy (so-called "Kirksite") dies has thoroughly established itself during this war. This article presents the practical details of the techniques and methods employed to make zinc alloy blanking and forming dies at a large midwestern aircraft plant.
—The Editors

THE WAR EFFORT is revolutionizing the historic character, identity and enterprise of many United States cities. None has undergone a more significant metamorphosis than Kansas City. The huge North American Aviation Co. is a dramatic example of what has occurred to Kansas City industrially. It is one of the largest plants producing medium bomber aircraft in the world. It completely fabricates the B-25 Mitchell which is raising such havoc on so many war fronts.

It is the purpose of this article to draw camera and text into sharply detailed focus upon one important phase of shop practice in this bewildering maze of "know-how," and to supply useful information having possibilities of extensive application elsewhere.

One of the big problems in airplane fabrication originates from the rapidity of engineering changes, so that it differs from automotive mass production

(and always will) in that no one unit off the assembly line is ever quite like the one before. The aircraft industry cannot tool up once each year and forget about it. Tooling revisions are a daily, almost an hourly occurrence.

It has become essential, therefore, to develop some method of creating dies accurately, economically and speedily; sufficient for short runs; and capable of being used while permanent dies are in work, if that appears to be required. Thus, the aviation industry has developed Kirksite dies which make possible projecting an engineering idea from the board through fabrication and into assembly swiftly, and at a fraction of the cost of permanent, steel dies.

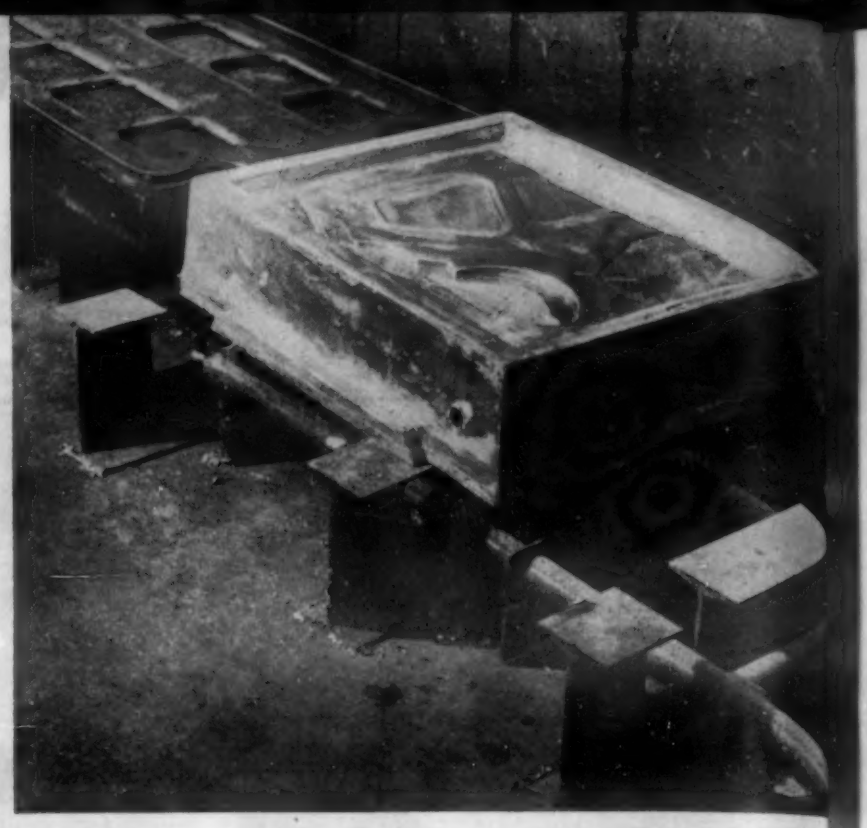
While expensive die steel has to be scrapped, Kirksite (an alloy of zinc, aluminum and copper and traces of other metals) can be remelted with little loss. N.A.A. at Kansas City has refined the art of Kirksite die making to the point where broken Kirksite dies or obsolete editions are remelted with a loss of less than 3.5%. It offers considerable solution to the problem of swiftly, economically and efficiently tooling up for new peacetime models essential to reconversion. The Kirksite procedure in the Kansas City plant is, therefore, subsequently detailed. It is explained as it was observed and concerns only the practice in this single plant.

Operations and Material Processed

Three types of Kirksite dies are employed by N.A.A. Inc.: (1) Quick tooling, cast Kirksite blanking dies, (2) conventional blanking dies, (3) cast forming dies for drop hammer or stretch press use. The temporary tooling section is under the jurisdiction of the manufacturing, rather than the tooling department. It is set up for quick, temporary die making.

A great variety of blanking dies, many of most irregular contour, are produced. Size is limited to an approximate 8 in. sq. Generally, these dies are designed to be used only until the permanent tooling is ready, work on it proceeding while they are in use. Cork and rubber strippers are used. Strippers are usually set 1/32 in. higher than the die. Blanking on these dies is successful on 24ST aluminum alloy up to 0.064 in. thickness. It has been used on 0.078 to 0.081-in. material but the results are not too good. The aluminum range is 24SO or ST to 52S and in gages of 0.025, 0.032, 0.040, 0.051 and 0.064 in.

The number of pieces that can be punched with these dies varies with the thickness and type of material. N.A.A. has produced 1300 blanked pieces of 0.032 in. ST from one set of dies still in use. A probable average without sharpening the die is from 300 to 400 pieces. The dies can be sharpened any number of times. All die plates are ¼ in. backed up with mounting plates. The time required from template to part to create Kirksite piercing and blanking dies average between 3 to 4 hr.; the process being geared to immediate changes. It would require at least three times that interval to produce steel dies, considering heat treatment, etc., and the cost of steel might be far greater than a 10 to 1 ratio, compared to Kirksite, the latter material being also recoverable by remelt.



Before the lead punch is poured in the die shop, the die is pre-heated over gas burners. The die is heated to approximately 300 F. before pouring the punch.

Rapid Casting of Blanking Dies

Steps in fast casting of these Kirksite blanking dies by this N.A.A. temporary tooling section method, are:

In creating the punch pattern from cold rolled steel, it is worked to the template, sawed on a dual band saw, finished on a jigged file grinder. This punch is then placed in the mold and fastened by C clamps.

The mold is of ¼-in. boiler plate. The inside of the mold is coated with red oxide to prevent the Kirksite or pattern steel from sticking to it. The mold is heated until it is nearly red hot. This requires about 2½ to 5 min. in a gas-fired furnace.

A gas-fired Knapp Kirksite 1000-lb. pot is used to melt the die metal, a temperature of 820 to 850 F. being the best pouring temperature. The mold is taken out of the furnace in its near-glow condition, placed in vertical position on a stand for easy pouring. One of the secrets of good die making is to flow the zinc alloy in fast, pouring from one side to permit air escape. The faster the pour, the better the results.

The zinc alloy should be permitted to cool at least 15 min. It should not be removed from the mold too fast, since it cools faster than steel. It should never be cooled or quenched in water. Kirksite tends to crack towards the center. Complicated contours should be kept at the mold top and turned where the air can best escape. No clearance is allowed between the die and punch. It is not ground or finished. The steel punch broaches the Kirksite. Only the cutting edge of the zinc alloy is finally finished. The face of the Kirksite die is ground on a belt sander, never a surface grinder.

The pour is taken from the mold, the punch being inside the die. Shoes are installed top and bottom and clamped in a jig. All die shoeplate holes are lined and drilled before the punch is removed from the die to assure perfect alignment. The punch is removed from the die, using an arbor press to force it out.

The punch and die are fastened to their respective Universal die shoes. Shoe sizes of Nos. 2, 3, 4, 5, 6, 7, 8, 10, 12, 14 and 16 are used. No. 2 is a 4-in. and No. 16 a 12-in. shoe: If required, holes for punches are drilled before the punch is removed from the die. After removal, punches are inserted and assembled on shoes, then ground.

Cork or rubber strippers are installed, cork for the male punch, rubber on the female Kirksite die. Cork is a failure as a stripper on the latter, in that it lacks springback.

When the emergency run on such temporary Kirksite dies is completed, the die is returned to the control crib to await the permanent die which is in work while this fast tooling is being employed. After 30 days, such Kirksite dies are passed to remelt.

Blanking Dies for Larger Work

The conventional Kirksite blanking dies are employed on larger jobs, limited only by the size of the press. They employ a steel punch. The largest being created at the time of observation was that of blanking a former in the airframe's center section. It had approximate dimensions of 5 ft. by 6 ft. and very irregular contour. Kirksite is impractical on duralumin over 0.064 in. It comes in ¼, 5/16 and ⅜ in. thickness in 36 by 36 in. and 18 by 72-in. sheets.

A typical 4 by 6-in. die job can be turned out in from 8 to 12 hr. The main steps in the process are:

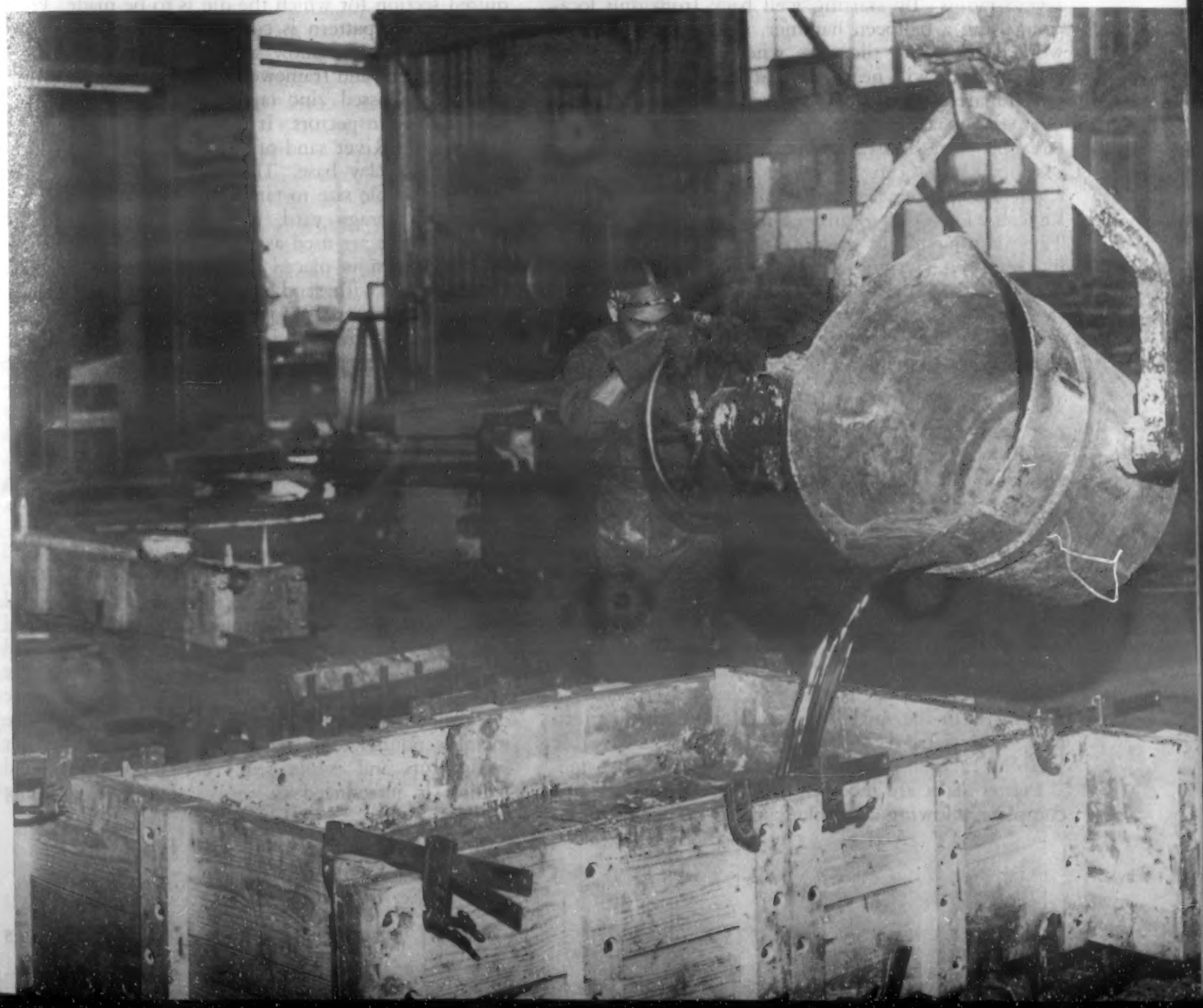
The outer contour is laid out from the template received from the loft department. The punch and die are worked together. The punch is of oxidation-resistant chromium-molybdenum steel containing approximately 1.5% Cr and 0.5% Mo. One die maker develops the Kirksite female blanking section, another the steel male punch.

The male section is flame hardened after it has been sawed, ground and fully developed. Flame hardening is used so that only the cutting edges will be case hardened by heat treatment. Male and female sections are mounted on respective plates and the complete die is taken to the nearest press of sufficient capacity where the Kirksite is sheared in.

The shearing process consists of pressing the male section contour from 1/16 to ⅛ in. into roughed opening in the Kirksite. The shearing stress has to be watched. The Kirksite plate is dismounted and taken to the bench where the die maker, working from the recessed impression in the upper surface of the Kirksite plate, produces the female die, undercutting it for relief.

Both sections of the die are drilled and reamed for mounting on standard shoes. N.A.A. regularly runs off several thousand pieces on such dies, varying with the material. The Kirksite can be re-sharpened by peening the edges of the die over with a ball hammer.

Pouring lead for a punch. The lead is poured in the finished Kirksite die after pre-heating the die, which has been sprayed with iron oxide to prevent the two metals from burning together.



Plaster molds of various forms in a stage before being used to make an impression for the Kirksite die.

There is a work tendency to develop a somewhat severe radius. By starting well back from dull location, using a ballpeen hammer, new material can be worked back into the edge where, broached by the steel male, it will neatly re-sharpen.

Compared with steel dies, Kirksite saves about 40% die making time. It is far easier to machine and file. An equivalent high-production steel die costing $1,000 can be produced from Kirksite at about $200, often less. Generally, Kirksite dies have sufficient longevity to answer all demands of the run. They eliminate the greatest portion of permanent die requirement with important savings in die investment.

Kirksite Forming Dies

Last of the N.A.A. types of zinc alloy die is the cast Cecostamp or forming die. A large and completely equipped foundry is maintained. Tolerances are established as close as ±0.015 in. The average casting can be completed from pattern to press in from 2 to 7 days. Castings up to 5 tons can be accommodated. N.A.A. originated hollow castings which will be later discussed. The main steps in this casting procedure are:

Upon receipt of the tool order, blue prints are drawn to determine the necessary templates. These are given to the plaster shop which models in U. S. Gypsum Red Top. The entire art of Kirksite die making is in the modeling of the mock up. Pattern makers must have the touch of the artist, a love for sculpture, and an unusual fidelity to precise dimension.

Plaster slabs are modeled with resultant mock ups complete, allowing a shrinkage of ⅛ in. per ft. From the mock up, plaster casts are taken from the required section for which the die is to be made. From this cast, the pattern is constructed.

The pattern is hollow with wood and hemp fibre reinforcement and framework. It is shellacked, identified by embossed zinc tape, checked and approved by company inspectors. It is then ready for the sand molds. Red River sand of the best grade is used because of its clay base. The pattern is scaled and a flask of suitable size to ram up the pattern is secured from the storage yard, together with two follow boards. These are used as boxing to confine the sand.

The pattern is placed face up in the flask. The flask is filled with sand. The sand is packed solidly around the pattern. Molding is done on the floor. The second follow board is fitted over the top of the flask which is then filled level with sand and the mold is secured by special clamps. An overhead crane inverts the entire mold. The pattern is withdrawn from the sand mold, leaving an exact reverse impression of the pattern.

In the meantime, Kirksite has been cooking in an open, gas-fired pot capable of handling 3½ to 5 tons of metal. Reaching its molten state, a pouring temperature between 750 and 850 F. is established and the pot is electrically tilted into pouring position.

A crane ladle is lowered to the pot front, the metal pour transferred to it and then ladled into the mold through gates to prevent rough facing on the finished casting. The pouring is at one end of the mold, the flow being into a reservoir which assures gentle dispersion of the metal throughout the mold. The mold is poured to within 1 in. of level full. After setting up and while still very hot, added hand ladling is introduced to the casting as a levelling device.

When the casting has sufficiently cooled, it is removed from flask and sand by crane and it is then placed in the cooling area for from 4 to 6 hrs. The die finisher then works from templates and blueprint. By special scraping, cutting, grinding, polishing, the die is brought to a near mirror finish. When finished, the die is moved to the punch boring section and placed over a gas flame for pre-heat.

When a temperature of 300 F. is reached, it is boxed up, asbestos covers being clamped tightly around the die. Molten lead is then poured over the face of the boxed die. Upon solidifying, this becomes the male punch or exact reverse of the female Kirksite die.

While the lead is still molten, a special jig is set over the die to locate anchor nuts in the punch which secure it to the press ram. The bottoms of both die sections are planed and are then ready for installation on the drop hammers, Erco stretch presses or Toledo mechanical forming presses used for the shaping of sheet metal parts. Chambersburg 3 to 5-ton air hammers are used.

All finished patterns are put in pattern storage and are used again in case of die breakage or if replacement is required because of excessive wear.

Hollow Dies of Kirksite

When Kirksite became critical and serious shortages appeared, N.A.A. set aside precedent, originated hollow dies and thereby saved thousands of pounds of this interesting die metal. An example: A certain punch, pressure plate die set when made solid, weighed 7,200 lb., and by the hollow coring method weighed only 2,820 lbs.—a saving of zinc alloy of 39%.

The secret of this coring method is the use of "green sand." Zinc alloys like Kirksite shrink as they solidify with predictable reduction. Baked cores disturb normal cooling, create die buckle and warp. "Green sand" eliminates this hazard.

Originated at the N.A.A. Inglewood foundry, the hollow die method is now standard in all plants. A Kirksite arbor for the "green sand" core is prepared in this manner:

Space for the metal reinforcing ribs of the finished hollow die are arranged by placing wooden ribs in the shell at right angles to each other, and a "walk over" hand packs the fortified shell with "green sand." Dowel holes (⅝ in.) in the pack are interconnected by grooves which together form the arbors for the core when molten Kirksite is poured into them. A U-shaped lifting channel the full length of the core box is created by ⅜-in. rod reinforcement, extending well into arbor frame contact.

These arbors, set in 20 min., are pulled and cleaned, and given a clay wash to hold the core sand. Then they are placed in the core box, still clamped to the channels and "green sand" is rammed home around the rib areas. Ribs are cautiously removed. Arbors are left with "green sand" pack. Cores are removed as a unit by their channel attachments. The cores are sprayed with plumbago and molasses water (special mix) to achieve a hard core crust. Placed carefully in the sand mold of the plaster pattern, the channel attachments are anchored to prevent wobble and distortion. Then Kirksite is gently ladled into the cavities. When cooled, cores and arbors are removed, achieving the hollow die properly reinforced with Kirksite supporting ribs.

This, then, is a brief description of the N.A.A. technique of Kirksite die making; one of the great contributions of the aviation industry to swifter, more economical and efficient tooling for relatively short-run work. It should have attractive applications in many industries, permitting speedier, cheaper conversion with distinct shortening of the time lag otherwise required in the tooling and introduction of new models at the war's end.

An aluminum part of a B-25 Mitchell bomber after it has been formed in a drop hammer.

Polishing a Kirksite die in the die shop.

(Continued from page 31

Any sudden cooling was frowned upon as disastrous. This practice, however, was a decided improvement over a still earlier custom by some of considering a steel casting annealed if it were red in color no matter by what process it had reached this condition. The actual crystalline appearance of a fracture was not then considered.

Partly as a result of experience during the first World War, the former conception of heat treating steel castings was radically altered. This constitutes the second stage. It was found that more or less sudden cooling in the air was beneficial and that no actual harm to the product was involved. On the contrary the microstructure was refined and the physical properties decidedly improved. This technique has been characterized as normalizing—cooling in the air from the proper heating, followed in some cases by reheating to a lower temperature.

The third stage in this progress is the most radical one—quenching the heated castings in water (or oil) followed by proper tempering. In our practical steel foundry experience we recall with what horror any such suggested practice was regarded some years ago —such treatment would involve the cracking and destruction of the product with other dire consequences!

As a result of experience in this war in making many types of steel castings for war munitions, demanding superior physical properties, the water quenching and tempering technique has been perfected and adopted by many producers as safe modern practice. It has resulted in physical properties superior to those obtained by any other technique. One of the best examples of this is the heat treatment of hull castings for tanks. Desired high physical and ballistic properties have been attained that could not have been secured by earlier methods.

A prediction of an authority in the steel foundry industry is worth quoting: "It is believed that in a ten-year period following the present war, approximately 50 per cent of the alloy steel casting production will be produced for sale as liquid quenched and tempered castings." We subscribe to this forecast and believe it will apply also to carbon steel castings.

This brief review emphasizes the progress which has been made, due largely to the demands arising from war. It is perhaps unfortunate that such a cause should be necessary to bring about progress of this nature. It would have possibly taken several years longer to attain these results, had it not been for the war. In any event steel foundry engineers and metallurgists deserve high praise for the results accomplished and for their contribution to the war effort.

—E. F. C.

Engineering and the Election

At the time of writing this the Republican party has just nominated its candidates for president and vice-president and the Democrats are getting ready to nominate theirs. This year we are *really* at the crossroads, according to both parties, and there is little hope for America—indeed for civilization— if these warnings be not heeded, etc. etc.

No one can deny that this election is important, but engineers, we think, may regard the election as of considerably less significance than other matters now engaging their attention and will be forgiven for believing that the sum total of human progress to date owes more to engineering and science than it does to politics and economics. Things will run a lot more smoothly, no doubt, and with less financial, social and material waste in war or peace when the executive and administration in Washington are efficient, well-organized, internally harmonious, logical in their approach to new problems and fair in their attitude toward the various segments of the American economy. But—the engineer inevitably reasons—the difference between one group of politicians and another must remain merely one of degree so long as politicians and not engineers control the utilization of the world's resources.

Actually we engineers make an enormous mistake in this attitude. The work of Edison, Bessemer, Charles Martin, Hall, Marconi, the Wrights, and other engineers of the modern era has unquestionably brought more comfort and less drudgery to man than has that of any 6 or 7 contemporary politicians or statesmen, but that fact is hardly a sound basis for isolating our technical selves from the political and economic realm. On the contrary, it is strong support for the growing idea that what the administration of modern society needs more than anything else is for (a) engineers as individuals and (b) Engineering as a collective force to become increasingly influential parts of the machinery of government. Ours is after all a technological civilization; indeed in its greatest crisis this country called on its *engineers* to build, design, produce and *manage* our way out of the colossal military unpreparedness into which politicians of both major parties—despite the warnings of informed engineers—had let us fall.

Yes, engineers have a powerful obligation to Society to participate in its politics. Politics is beneath us only because we have disdainfully let it remain so. Engineers and the executives of engineering enterprises must broaden themselves, improve their general information, study people and politics, analyze political administration, and dissect the problems and personalities of political economy just as they are already successfully investigating and solving the no less complex problems of electronics, mechanics, metallurgy and so on.

This election could be the most important one in American history if it but initiated the ascendency of the engineer in the management of this country's social, political and economic affairs!

—F. P. P.

MATERIALS & METHODS MANUAL

1

This is the first in a series of Manuals on engineering materials and production methods, to be published at periodic intervals as special sections in Metals and Alloys. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal-forms or with essential principles, best procedures and operating data for performing specific metal-working processes.

Selecting Production Methods for Small Parts

a Design Comparison of the Precision Metal-Forms

by FRED P. PETERS, Metals and Alloys

War-product design and manufacturing have sharply revealed the need for compact, concise, all-in-one-place information on the design features, advantages and disadvantages of the various methods of manufacturing small parts on a high-production basis. Such engineering data and descriptive information have therefore been assembled into this "manual," intended to serve as a guide to process and form selection for the engineer (1) seeking to maintain production levels with reduced manpower and machine-time or (2) investigating feasible fabricating methods for post-war products.

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Metals and Alloys, July 1944

Introduction: The Engineering Problem

ONE PHASE OF MATERIALS ENGINEERING that often receives less attention than it deserves is the specification of "metal-forms" or fabricating methods. Not only do *materials* as such compete for the designer's attention, but also the *methods* that can be used to manufacture specific parts and products are a matter for choice, and in many cases become the primary factor in deciding which material will ultimately be used for a particular job.

Thus, in developing his design, the engineer must normally give consideration to the factors of functional utility, mechanical quality, appearance and production cost. When the product or part is to be manufactured on a mass-production scale the factor of production cost may easily predominate over the others. In such instances the first and most important choice may be how the part is to be made—shall it be a die casting, a screw-machine part, a stamping, a brazed assembly, or what? Furthermore the choice of method assumes especial importance in any wartime design program because of the large effect such choices have on the conservation of production manhours, machines and materials.

Process-specification has become in this war a branch of materials engineering just as important as selecting the materials themselves. We are at last learning that each high-production method has certain "design characteristics" as distinctive of it as are the typical properties of individual metals or alloys. It is the purpose of this manual to describe and compare these characteristics of the more common methods for mass-producing small parts in such a way that the design-, process- and production-engineer may find herein a convenient guide to the selection of fabricating methods for various design situations.

Small parts (i.e. up to 12 in. in any dimension and no heavier than, say, 50 lb.) for industrial and consumer products may be made by any one of 15 to 20 methods. The most important of these are:

SAND CASTINGS	IMPACT EXTRUSIONS
PLASTER MOLD CASTINGS	STAMPINGS
PRECISION (INVESTMENT) CASTINGS	WELDED OR BRAZED ASSEMBLIES
PERMANENT MOLD CASTINGS	SCREW-MACHINE PARTS
DIE CASTINGS	TUBING PRODUCTS
DROP FORGINGS	EXTRUSIONS
PRESS FORGINGS	SPINNINGS
UPSET FORGINGS	POWDER METAL PARTS
COLD HEADED PARTS	MOLDED PLASTICS

In making his choice among these metal-forms for the manufacture of a particular product, the engineer sets forth his minimum requirements as to certain selection factors, determines which forms meet these minima, and then compares or rates those that are suitable as to their relative appeal. These bases or criteria for metal-form selection fall into three groups

"DESIGN" FACTORS (SIZE, SHAPE, STRUCTURE, ETC.)
PRODUCTION SPEEDS
COSTS

Under each of these there are of course various subdivisions, many of critical importance in part design and process selection. All of them are listed and the comparative ability of the various metal-forms or production methods indicated in detail in the section "Cost, Design and Production Comparisons" starting on page 97.

Descriptions of the Methods and Forms

In the pages immediately following there are briefly set forth (a) the salient processing features of each method, (b) its advantages and disadvantages, and (c) illustrations of typical parts made by it, in such a way as to indicate very generally what each form or method can accomplish for the designer

PROCESS FEATURES	ADVANTAGES, ETC.	TYPICAL PARTS

Permanent Mold Castings

Permanent mold casting (called "gravity die casting" or just "die casting" as distinct from "pressure die casting" in England) involves pouring of the molten metal under a gravity head into metal molds. The molds are made in sections and assembled, and remain clamped together during pouring and solidification of the casting.

The materials cast are aluminum alloys, magnesium alloys, bronzes, cast iron, zinc and lead. "Slush castings" are those in which the still liquid internal metal is poured out of the casting after the outer shell has hardened; zinc and lead are the metals most used for slush castings. Small parts (aluminum alloys, bronzes, steel, etc.) are often centrifugally cast in metal molds.

Permanent mold castings are dense and fine-grained and can be made with better surfaces and to closer tolerances than sand castings. Tolerances are wider than die castings and plaster mold castings. Tool charges are lower than die casting but higher than sand and plaster mold casting. Production rates are lower than for the same parts made by die casting.

The process is thus seen to stand somewhere between sand casting and die casting in respect to possible complexity, dimensional accuracy, mold or die costs, direct labor costs and production rates. For many parts it provides an attractive compromise where the ultimate, either in complexity of one-piece construction or in narrow tolerances or ultra-high production, need not be met.

Courtesy: The Permold Co.

PROCESS FEATURES	ADVANTAGES, ETC.	TYPICAL PARTS

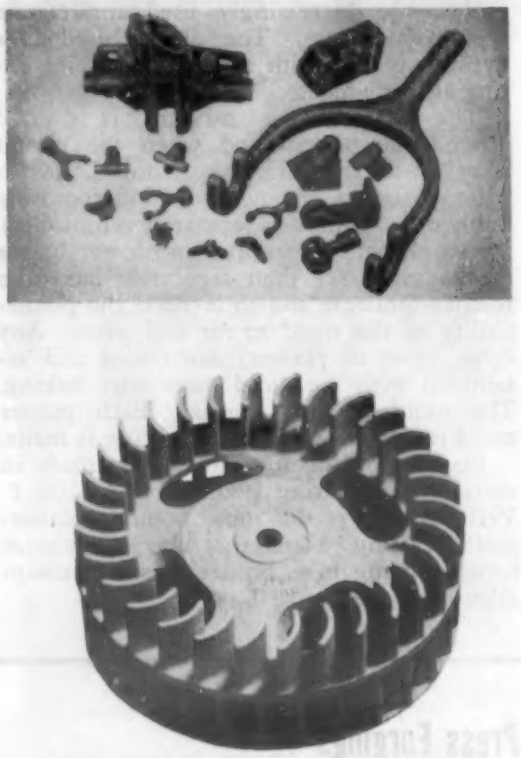
Sand Castings

Sand casting is the traditional and still the most common method of producing castings. It consists in (a) making a sectioned wooden or metal model (called a pattern) of the part to be cast in the closest possible approach to actual size (with due allowances for shrinkages in solidifying and for surface machining on the casting), (b) packing molding sand around the pattern in a "flask," removing the pattern (and sometimes drying the mold by baking it), (c) inserting dry sand cores in the mold to leave cavities where desired in the casting (which might otherwise have to be drilled or bored), (d) melting or alloying metal usually under careful metallurgical control, in a furnace or cupola and pouring into the mold cavity, which must be provided with "sprues and gates" for entry and disposition of the metal during pouring and with "risers" to carry out dirt and to provide a feeder reservoir during solidification. When it has solidified, the casting is "shaken out" of its mold, the latter being destroyed and the sand returned for reuse or discarded.

• The casting usually must be machined to finished dimensions since its surface is rough and the sand mold lacking in precision. Sand casting's tolerances are wide—±1/16 to 1/32 in. per in. being normal for the process.

For small parts sand casting can be very rapid, since several molds may be poured simultaneously. Tool costs are low, for expensive steel dies or molds are not involved, but labor costs are likely to be high. Its design flexibility—i.e. the ability to make complicated, cored and undercut parts in one piece—is very high, since the mold is expendable and cannot interfere with the removal of even the most complicated shape after the latter has been cast.

Sand castings may be very large—several feet in height or width, but they cannot be as small nor as thin-sectioned as parts made by other methods. Gray cast iron, malleable cast iron, steel, brass and bronze, aluminum and magnesium are the materials in which most sand castings are produced.



Upper—Steel Castings (Courtesy: Steel Founders' Soc. of America); Lower—alluminum alloy casting.

Die Castings

Die casting is done in fast-working machines that transfer or inject under pressure the right amount of molten metal into a metallic water-cooled die set that remains closed until the casting is solid. Half of the die is stationary and the other half moves on a carriage. After the casting is solid it is removed from the movable half of the die by mechanically operated ejector pins.

There are 3 types of die casting machines —(a) gooseneck or direct air injection machines, in which the metal is held in a pot and is forced through a gooseneck outlet into the die by admitting air under pressure; (b) plunger machines, in which air or hydraulic pressure pushes a cylinder immersed in the molten metal, injecting the latter into the die; and (c) cold-chamber machines, which have an injection ram in the cylinder, the ram being filled by ladling in just the right amount of molten metal.

Gooseneck machines are used for aluminum, plunger for zinc and aluminum, and cold-chamber for magnesium and copper alloys and increasingly for aluminum. Pressures run 500-600 p.s.i. for gooseneck, 1500-3000 p.s.i. for plunger and 600-20,000 p.s.i. for cold chamber. Production rates are up to 110 shots an hour with gooseneck, 100-400 (in extreme cases 800) with plunger and up to 90 with cold-chamber. On any machine the use of multi-impression dies can increase hourly part-production several fold.

Die casting's strongest points are its excellent precision (tolerances as close as ±0.001 in. can be held) and the high production rates often achieved. Because die castings seldom need to be machined to meet tolerances and because of the high productivity of the process they are among the most economical of the mass-production metal-forms.

On the other hand die costs are a sizeable factor, although not so great as for some of the solid-metal-forming methods. Casting shapes are limited in complexity, for undercuts and cross-holes cannot be included unless the dies embody expensive slides, collapsible cores, etc. The cost of these extra die features can often be justified; sometimes the use of an exterior undercut saves metal by providing uniform section thickness, or, again, a part with necessary undercuts may still be less expensive to make by die casting than by other methods.

Because of the effect on die costs, die castings are chiefly made in low-melting-temperature metals like zinc alloys, aluminum and magnesium alloys and in general their mechanical properties are therefore lower than metal-forms like machined steel, steel forgings, high-strength iron sand castings, etc. But die castings as a class are not at all the unsound, porous and weak materials of many years ago, and where maximum strength is not required they are serving nicely today for many applications even of a structural or engineering nature.

Most die castings are made in zinc alloys, although the proportion made in aluminum alloys has sharply increased. Magnesium alloys, too, are increasingly used for die castings. Where high mechanical properties in a die casting are sought, brass may be employed, although die costs are thereby raised considerably.

Courtesy: New Jersey Zinc Co.

Courtesy: Aluminum Co. of America

PROCESS FEATURES	ADVANTAGES, ETC.	TYPICAL PARTS

Plaster Mold Castings

Plaster molds, primarily because of their fine finish and improved accuracy over sand molds, are increasingly used for certain types of castings. The plaster used is a gypsum plaster with strengtheners and setting agents added.

The plaster-water mixture is poured around the pattern and when the plaster is partly set the pattern is removed. Match plate patterns, sometimes incorporating many metal patterns (separately removable) are employed. The upper and lower halves of the mold are then separately baked to remove moisture and to increase the permeability of the mold to air and gases. Any cores (also of plaster) are baked and assembled with the mold parts after baking. The mold is then poured. Each plaster mold is broken up after the casting is made.

Plaster-mold castings are seldom made in metals with melting points above 2100 F. Yellow brass is the most popular plaster-mold casting material, with aluminum bronze, manganese bronze and aluminum alloys also used.

Plaster-mold castings have surface finish and dimensional accuracy far superior to sand castings. The method can be used to make castings directly to size if the tolerances are no narrower than ±0.005 in. per in. Surface finish, reproduction of fine detail and metallurgical structure are superior to sand castings. Molding cost is higher than for sand castings, but of course subsequent machining costs are less.

Plaster-mold castings are slightly inferior to die castings and permanent mold castings with respect to dimensional accuracy and surface quality. Very thin walls can be cast. Plaster-mold castings are usually most economical for short run work but with a highly mechanized set up can compete on a cost basis with metal mold castings for mass-produced items. The plaster-mold castings seem especially attractive for medium-run pieces which could not absorb the cost of metal molds but which would involve too much machining if made in sand molds.

Courtesy: Briggs Mfg. Co.

Press Forgings

Press forgings (also called hot pressings or die-pressed parts) are made in either hydraulic or mechanical presses. A hot billet or slug of correct diameter and length is placed in the die impression and pressure exerted to make the hot metal flow and fill the die cavity. The process is carried out in either one operation or in successive stages with several die impressions, but no such preliminary operations as edging and blocking can be performed.

Parts are ejected, when the die is open, by knockout pins, hence little or no draft is required. Dies are of three types—"open" (similar to drop forging dies, with one plane of parting); "extrusion" (the metal flows into an annular space between a punch and the die cavity); and split dies, which permit the forging of flanges and other projections that otherwise could not be removed from the dies.

Press forgings can be made to somewhat closer tolerances, require less draft and permit greater design intricacy, than drop forgings. Although conventionally used for smaller forgings than the drop hammer process, press forging has recently benefited from the construction of very-large-capacity presses capable of making surprisingly large parts. Press forgings as heavy as 25 lb. can now readily be made.

A large proportion of nonferrous forgings are press-forged, and steel forgings (small-to-medium-sized gear blanks, for example) are frequently made in presses. With the above-mentioned exceptions, press-forgings are similar to drop forgings in their competitive relations to other metal-forms. For high-production work, where their degree of precision is adequate and especially where highest mechanical quality is required, forgings of any type will be eminently satisfactory.

left: finish-machined; right: rough aluminum forging
Courtesy: Wright Aeron. Corp.

Courtesy: American Brass Co.

Upset Forgings

Upset forgings are made in upsetters or forging machines out of bar stock. The heated bar is held between two stationary gripping dies, and is then struck axially by a heading tool. The stock is thereby shortened axially while being thickened over part of its length.

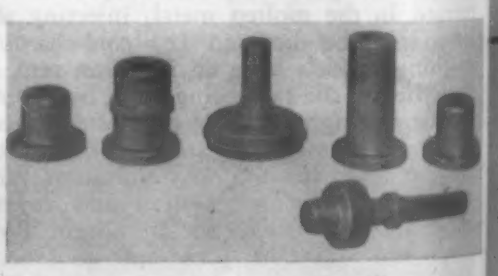
Many types of upsets may be produced in a given machine by varying the heading tool or gripping dies. Punches are used instead of heading tools when a forging is to be pierced or made hollow. It is common to upset-forge a part in successive steps without reheating, by striking the stock with a series of heading tools as the stock is progressively shifted in the gripping dies.

The greatest length of stock that can normally be upset in one blow is 3 times the original bar diameter, if the upset portion is not contained in a die cavity. If it is so contained the limiting length is longer.

The characteristic feature of upset forgings is their bar-stock basis. Small-to-medium-sized forgings have been best for upsetting, although forging machines are now used for large forgings like aluminum cylinder heads for aircraft engines and steel cylinder barrels. The maximum bar stock size that can now be handled in forging machines is about 9 in.

Upsetting can be done to dimensional tolerances of the same order as press-forging—slightly narrower than drop forging. Draft required is midway between the usual allowances for drop and press forging. Upset forging permits piercing out a hollow part, thus saving machining costs (as does the coring in sand casting).

Like other forgings, upset forgings are tougher than many other metal-forms; and require far less machining to size than do sand castings, about the same as permanent mold castings and more than die castings or powder-metal parts.



Courtesy: Tube Turns, Inc.

PROCESS FEATURES	ADVANTAGES, ETC.	TYPICAL PARTS

Precision Investment Castings

The increase in industrial use of precision castings made by the "lost wax" or similar fusible pattern process has been one of the significant wartime production developments in metal-working. The method comprises (a) the production of a split section master metal mold from a replica or model of the casting; (b) pouring wax into the cavity of the master mold, (thus forming a wax pattern that duplicates the dimensions and details of the original model), and removing the split-section master mold; (c) placing the wax pattern in a flask and pouring the mold investment (plaster, ceramic or other castable material) around it; (d) when the investment or mold has hardened, melting out the wax, leaving a mold cavity in which the casting is poured.

The investment is broken up to remove the finished casting, but because the pattern is liquid and can be poured out of its mold in this way complicated designs with cross-cores and undercuts can readily be produced. Each investment can be used just once, but the master mold lasts indefinitely.

Model, wax and investment materials are selected so that the expansions and shrinkages involved tend to cancel each other out. Final casting of the liquid metal is done either centrifugally, or under pressure, or sometimes in a vacuum.

Because the mold in which the final casting is made is broken up and discarded in removal of the casting, designs may be very intricate. The method in fact combines the permissible design-intricacy of sand casting with precision close to that of die casting (tolerances may be from ±0.005 in. to 0.003 in.). Considerable skilled labor is involved and there is some material waste in the form of sprues. Normally no (or little) subsequent machining is required.

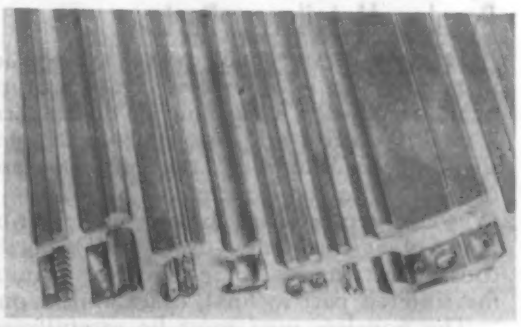
Production rates may be high but for very small parts cannot compare with die casting or powder metallurgy. Costs can be low, especially for moderate-production work or in competition with machining for complicated parts. Once made only in precious metals, precision castings are now made industrially with brass, bronze, Stellite, Vitallium, stainless steel, etc. It is useful for making precision parts out of materials that are difficult or virtually impossible to machine. A particularly valuable niche for it appears to be the production of parts to closer dimensions than can be had by sand casting in shapes too complicated for powder metallurgy and out of materials of too high melting points for die casting.

Courtesy: T. G. Jungersen, Arocast Mfg. Co.

Cut Extrusions

The parts-manufacturing method falling under this head is simply the purchase of very long extruded pieces of special cross section uniform throughout their length, and cutting them up transversely to produce parts shaped like the special cross section but with thicknesses equal to the cut lengths. The cross-section, in any case, must be one capable of extrusion at the mill (done by pushing the hot metal through a restricted die orifice in a hydraulic extrusion press), and might be a solid circle, a hollow circle, a T, an L, a U, a rectangle (solid or hollow) or some intricate and irregular-shaped variation of any of these.

The chief advantages in the use of cut-extrusions for small parts are the feasibility of obtaining irregular or unsymmetrical shapes that are difficult or expensive to produce otherwise and the excellent mechanical properties of the extruded materials. The method is of course specially applicable for parts having a uniform width or diameter along their thickness or length. Brass and bronze, aluminum alloys, magnesium alloys, lead, tin and zinc alloys are available as extrusions and can be cut into small parts by this method where design permits.



Courtesy: American Brass Co.

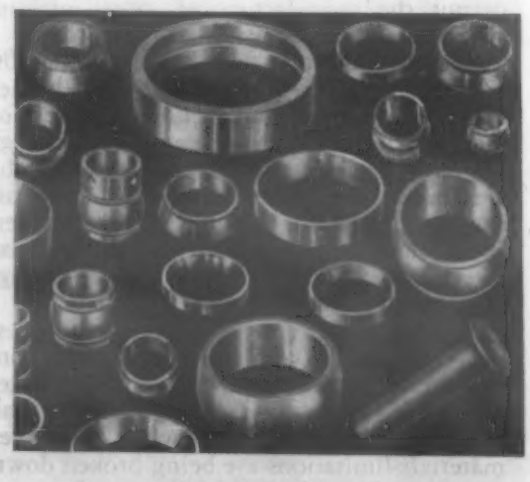
Sectioned Tubing

Sectioning tubes is directly analogous with extruding and cutting, discussed above. Tubing (not necessarily seamless) of a given metal is purchased from the mill in specified i.d. and o.d. and then accurately cut up into very short lengths, which in effect become the thicknesses of flat-faced rings. The tubing may be pierced-and-drawn, welded or extruded; for highest precision parts the seamless tubing is preferred. The cut tubing is frequently further processed by flaring, expanding, upsetting, bending, tapping, etc. to form more complex parts.

Tubing is available in virtually all wrought metals, steel, alloy steel, stainless, copper, brass, bronze, aluminum, etc.

Cut tubing competes with punchings and stampings and with powder metallurgy parts for such applications as bushings, seals, retainer rings, metal washers, liners, gaskets, etc., where the thickness (i.e. the height) of the cylinder is small in relation to the wall thickness. For relatively long, thin-walled open-ended cylinders only cut tubing (or perhaps impact extrusions with the closed and knocked out) can be used. Thick-walled long cylinders can be made by casting methods, by machining bar stock, or by cutting tubing.

Cut tubing is an extremely economical form and has sufficient accuracy for many precision applications in small parts.



Courtesy: Babcock & Wilcox Tube Co.

PROCESS FEATURES | ADVANTAGES, ETC. | TYPICAL PARTS

Drop Forgings

Drop forging (or more accurately but less commonly "impact die forging") consists in working a billet (usually round-cornered square stock) of hot metal to approximately its final form by repeatedly hammering it on a board, steam or air drop hammer while it is enclosed in suitable dies. The die block usually has 3 impressions—an edger, a blocker and a finishing impression—which work the stock in progressive stages. No intermediate reheating is required. The flash surrounding the forging is removed in a trimming press.

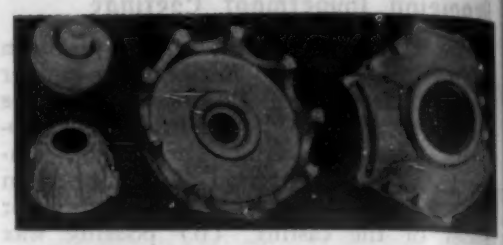
In the board drop hammer the force of the blow is imparted solely by the falling weight of the ram containing the upper die; the speed of fall is about 14 ft. per sec. The largest board drop hammer today is rated at 5000 lb. falling weight. The steam or air drop hammer adds positive pressure to the force of gravity, so that the ram falls at the rate of about 30 ft. per sec. Present maximum steam-hammer rating is 50,000 lb.

Production rates vary, depending on the material, size of hammer, etc. For hammers of greater than 2000 lb. falling weight, output may be in the neighborhood of 15-30 lb. of forgings per hour per 100 lb. of falling weight, the higher rates applying to a low-carbon steel and the lower to high carbon steels and light metals.

A chief advantage of drop forging over press forging and upset forging is the former's use of 3 die impressions in one block and the absence of need for reheating. All forgings—and especially drop forgings—are noted for their strength or toughness, particularly in the direction of fiber or flow, and are superior to most other metal-forms in this respect.

Drop forging is usually favored for the larger sizes of forgings, but those weighing a few ounces (silverware, for example) are also made. Draft must be greater in drop forging than in press or upset forging. Design intricacy is limited in comparison with castings. Metal waste in forging is more than in die casting or powder metallurgy but considerably less than in sand casting. Tolerances can be held to ± 0.010 to 0.015, with ± 0.004 in. available at extra cost. This is much closer than sand casting's and finishes are better than by sand casting, too.

On the other hand forging dies cost more than casting-patterns. Die cost is so great a factor, indeed, that forging is generally not used for anything but high production work. The costs of drop forgings and castings in similar materials are comparable. The common drop forging materials are carbon steel, brass, bronze, aluminum alloys, magnesium alloys, and special steels.



Courtesy: Chambersburg Eng. Co.

Powder Metallurgy Parts

Fabrication of small parts by powder metallurgy methods involves (a) pressing of metal powders in a mold or die to form a weak, "green" briquette of roughly final shape, (b) "sintering" the briquette and bringing it to service strength by heating it to some temperature below the melting point of at least one (usually all) of the constituents, and (c) re-sizing or coining the sintered part to final, exact dimensions.

The powders used must be carefully selected for purity, pressability and size, and are blended under controlled conditions for best results. Presses used are either fast-working mechanical "tablet" presses (especially for very small parts) or slower-working hydraulic presses for larger parts. Dies are usually expensive and must be lubricated. Double-acting presses and die sets permit the manufacture of more intricate shapes than would otherwise be possible.

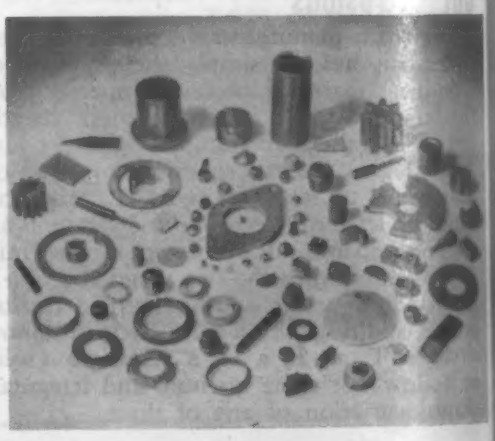
Production speeds usually run from 200 to 1600 parts per hour, but even higher speeds are possible and in use. A variety of materials are worked by powder metallurgy methods but those of most interest to the designer of small machine parts or industrial hardware are iron, steel, iron-copper, copper and brass, with or without admixtures of graphite, tin (with copper), tungsten (with copper and others), etc.

Recent improvements in powders, press sizes and speeds, coining practices, etc. continually lead to closer tolerances, larger sizes, higher rates or better properties than those considered feasible a while ago. Even materials-limitations are being broken down, with strong iron and aluminum parts now in commercial production.

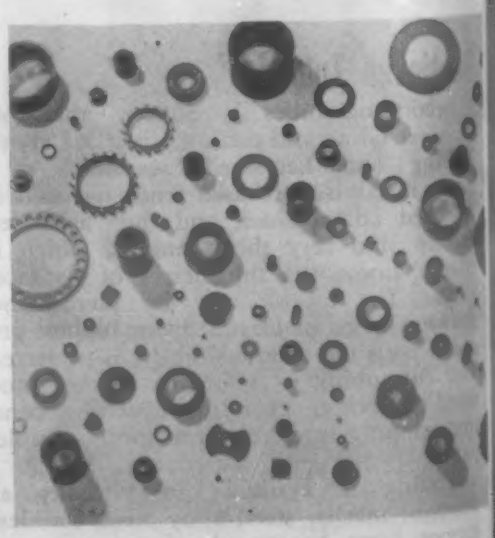
Powder metallurgy is able to provide certain structures or metal-combinations that are not producible by melting (and therefore by the other methods discussed in this manual). For such work—e.g. the manufacture of self-lubricating bearings, tungsten-carbide tools, porous metal filters and copper-tungsten and other duplex-structural contacts—it is competitively out of reach of the other processes.

It is also being used increasingly for making small parts on a mass-production scale to very close tolerances, in direct competition with machined parts. Tolerances can be held closer than ± 0.001 in. and production speeds of 1600 per hr. are not unusual. The method involves fewer total operations than some of its competitors; costly machining is largely eliminated and material waste is at a minimum because parts can be made directly to finished dimensions.

On the other hand, the part-shapes possible in powder metallurgy must be relatively simple, part-size is still generally limited by available press capacities, raw material costs are comparatively high and the mechanical properties of powder-compacts inferior to those of many other forms. Tool costs are high, but labor charges are low. The process is best adapted to large-quantity production, although it has been successfully used for short runs. For machine parts powder metallurgy thus excels chiefly for very-close-tolerance work on a reasonably large production basis, where considerable machining would be involved in the usual manufacturing practice. Of course, for certain special-structural effects or special materials it is in a class by itself.



Courtesy: Kux Machine Co.



Courtesy: Keystone Carbon Co.

PROCESS FEATURES	ADVANTAGES, ETC.	TYPICAL PARTS

Stampings, Formed Parts, etc.

Stamping may be defined as the blanking, pressing or forming of metal parts out of sheet or strip, using presses (or in some cases, drop hammers with soft dies and punches). The process involves (a) punching out a flat "blank" from the sheet metal, (b) forming this by bending or folding in a suitably-shaped die and often (c) drawing the metal by stretching it over or between parts of the die or punch.

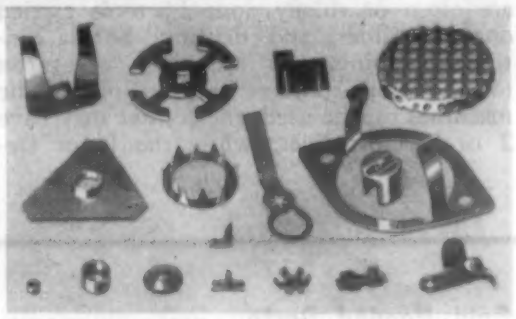
Stamping presses or punch presses are usually employed to make the parts, although blanks may be produced in shears and formed parts in brakes. The "die" (or "female die") is fixed to the bed of the press, while the "punch" is the movable member attached to the ram. Some presses and dies are designed to perform more than one operation (e.g. blanking plus forming). Compound piercing and blanking dies are also common. A sound, practical knowledge of die design, and of the types of forming that can be done in presses is especially important in the specification and design of stamped and formed parts.

Stampings and drawn parts (both are often called pressed metal parts) are characteristically mass-production forms, and on a strictly cost basis it is often difficult for other methods or forms to compete with them on runs of over 10,000 per piece: Their manufacture involves high tool costs, low raw-material costs, medium labor charges and some waste.

Very thin parts (thinner than those possible by powder metallurgy or die casting) can be formed to tolerances better than ±0.001 in.; larger parts must usually have tolerances wider than ±0.003 in. Production rates may be as high as 3000 per hr., and surface finishes are excellent.

Design-shapes of stampings are limited to those that can be formed of sheet metal. The materials that can be used, however, are plentiful, numerous and among the least expensive raw materials available. Steel, stainless steel, tinplate, brass, bronze, aluminum alloys, nickel, Monel, etc. are all widely used to make stampings. The war has produced a sharp trend toward this form; much has been learned about their design and about their often surprising economic utility.

Courtesy: Goat Metal Stampings, Inc.



Molded Plastics

Under the heading "molding of plastics", we are here including the production of parts made of certain synthetic resins and their compounds by (a) pressing to shape in a die or mold, (b) casting, (c) injection molding, or (d) laminating.

Plastics are often classed as either (1) thermoplastic (undergoing no chemical change on molding and capable of being softened for increased workability or re-use by heating or re-heating) and (2) thermosetting (permanently hardened by a chemical change when heated, as in the usual molding operation). Thermosetting materials are usually molded at higher temperatures than thermoplastics. A "molding compound" consists of a mixture containing the resin (which gives the plastic its name and basic properties and acts as a binder), the filler (which imparts strength or other special properties to the compound), plasticizers, dyes and perhaps lubricants.

There are many types of plastics compounds and a bewildering array of subtypes and individual materials, offering a wide range of properties and fabricating methods. Phenol formaldehyde is typical of the "phenolics"—thermosetting plastics low in cost and with good all-round properties. Urea formaldehyde compounds are similar but come in various colors. The melamine resins, also thermosetting, are intermediate in many respects between the phenolics and the ureas.

The best-known thermoplastics include the vinyls (some of which are flexible like rubber at low temperatures), the polystyrenes (light weight, strong, often transparent materials), the acrylates (transparent), the polyamides (strong, extrudable, fibrous), and the celluloses (high mechanical properties, variety of colors and opacities, workability). Also there are plastics made from casein, lignin, rubbers, etc.

The thermosetting materials are available in compression-molded, transfer-molded, (very recently also injection-molded) or laminated forms; thermoplastics can be compression-molded, injection-molded, cast, laminated, extruded and filmed.

The range of properties now available in plastics is astonishingly broad and the combinations and modifications possible of much interest to designers. In general plastics are highly attractive, colorful, sometimes translucent or transparent, resistant to atmospheric corrosion, and warm to the touch. Nearly all plastics are first-class electrical and thermal insulators. The number of fabricating processes permits considerable flexibility in design, although molded parts, for example, are subject to intricacy limitations similar to those existing for die cast, drop-forged or powder-formed metals. At present plastics are best suited to the molding of comparatively small parts having thin walls of uniform thickness and section.

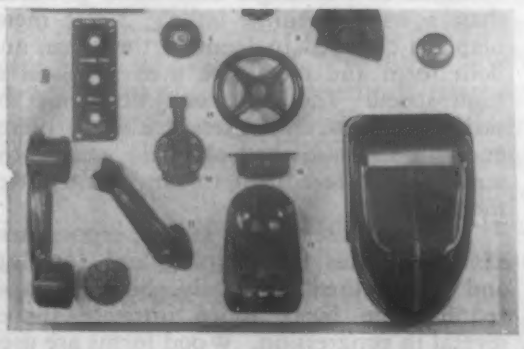
Plastics parts can be produced rapidly and often in multiple; the production rates of compression moldings are faster than those of most metal-forms of similar size except die castings, small powder metallurgy parts, punch press parts and some screw-machine products. Injection-molded parts can be produced at faster rates, but still slower than the speediest metal-forming methods. Dimensional accuracy is within the precision range; ±0.005 in. per in. are the commercial tolerances.

Raw material costs are still relatively high for all plastics compounds, although the prices for phenolics and other less expensive resins compare with those of magnesium, aluminum and copper alloys on a per-pound basis. Mold and die costs are relatively high, but labor charges can be very low because of the automatic nature of many of the processes.

Some plastics have good mechanical strength and great improvements have recently been made in this direction, but the number of "strong" plastics is still dwarfed by the number of strictly ornamental varieties. They are lighter, however, than metals and some therefore have interesting strength/weight ratios. Virtually no plastics can be used at temperatures over 450 F.

Molded plastics will compete with metal parts for a number of applications. But to an even greater extent metals and plastics can be used in combination with each other just as various metals and metal-forms have always supplemented each other in the design of individual products.

Courtesy: Monsanto Chem. Co., Plastics Div.



Courtesy: General Electric Co.

PROCESS FEATURES	ADVANTAGES, ETC.	TYPICAL PARTS

Screw Machine Parts

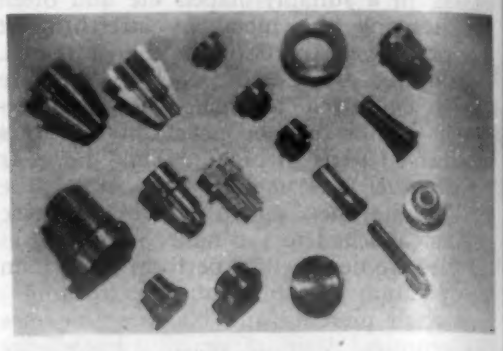
Screw-machine products are usually made on a hollow-spindle turret lathe designed for automatic operation. They are not necessarily screws or even threaded parts but include all types of small machined parts produced rapidly and repetitively from bar stock or tubing and involving surfaces that are turned, formed, faced, drilled, bored, threaded or cut-off; many of these last operations are performed simultaneously on the same machine. Burnishing is now also done on some machines with special spindles. Supplementary operations are also frequently done on separate machines.

Turning on the o.d., facing and cut-off are often or chiefly done by tools carried on cross-slides, and drilling, boring, internal tapping, etc. are done on turret tools. Single-spindle or multiple-spindle machines can be used; the former may have 2 or 3 cross-slides, while the latter frequently have one cross-slide and one turret tool for each spindle position, to increase the output.

Screw-machining's production rates are among the highest (up to 3600 per hr.) and its tolerances among the closest obtainable in any of the competing metal forms. The surface finish on a screw-machine product is smooth and lustrous.

There is on the other hand, considerable waste metal involved in the process and the design flexibility is not unlimited. Parts must have surfaces of rotation (although secondary operations like cross drilling done with attachments or on supplementary machines offer some flexibility). Interior and exterior undercuts not feasible in die casting and powder metallurgy are possible. Machines in common use can make parts up to 2¾ in. diam. x 6 in. long.

The automatic screw machine is usually not economical for short-run (less than 1000) jobs because of its high tool costs. The materials most used are free-machining steels, free-cutting brass, aluminum and magnesium alloys, other nonferrous metals and, increasingly, plastics. These raw materials (especially steel) are relatively cheap, while providing often better mechanical quality that can be had in sand-cast, die-cast or pressed-powdered metals.



From "Handbook on Designing for Quantity Production," By Chase, McGraw-Hill Book Co.

Cold Headed Parts

Cold heading is really a specialized form of upset-forging, done in somewhat different machines and on cold stock. Wire is taken directly off a reel, cut to required lengths and automatically put through the upsetting operations. The stock is gripped between dies in a header and pressure is applied upon the stock ends to produce a thickened section or flange wherever desired. Modern headers also can do some "extrusion" by driving the end or all of the shank into a hole of smaller diameter, with a proportionate increase in length.

Production may be very rapid, (e.g. up to 400 per min.) and the only supplementary machine-operations required are trimming, thread cutting or rolling and drilling of cross holes. The stock is cold-drawn wire up to 1 in. in diameter (usually less than 5/8 in., however) and 1/4 to 7 in. lengths (for steel). Carbon steels, alloy steels, stainless, aluminum alloys, brass and bronze—all essentially ductile materials—are commonly cold-headed.

Cold headed parts resemble those made on the screw-machine in many respects. The process is rapid, and involves no metal waste (in contrast with screw-machining). Because no heating is required (as in forging), surface finish is excellent, die costs are lower and tolerances can be more closely held (down to ±0.002 in. per in.).

Design intricacy is relatively limited, of course, the flexibility being of the same order as upset forging. The amount of upset possible is less than in hot forging, and part size is limited in comparison. The costs for the process show up best on simple flanged or headed products like bolts, screws and rivets in very large lots.

In small sizes or small quantities, especially where a threaded stem or the use of brass is specified, screw-machining may be preferable to cold-heading. Although tool costs are high, cold heading is one of the least expensive fabricating processes where large production is required and the design is suitable.

Spinnings

Metal spinnings are made by dishing sheet metal discs as they revolve on a lathe, using simple tools. The first step is the preparation of a wood or metal "form" of the exact shape and dimensions of the finished part. The form is fastened to a lathe (similar to but larger and more powerful than a wood turning lathe), a flat metal blank is clamped in front of the form, and both form and metal are then revolved at high speed. The operator (who must be skilled in this art) presses a long blunt-ended tool (hardwood or steel) against the metal blank, forcing it to flow snugly over the form.

The forms serve the same purpose here as do the dies in stamping and forming, and can be used repeatedly. Simple shapes require one form, more intricate shapes several in progression. Wood forms are used for small quantities or large sizes; steel forms for large quantities and small sizes.

The metal part is work-hardened during spinning and thus has extra strength and hardness.

The characteristic features of spinnings are their low cost for relatively small-quantity production, their generally concentric, round or cylindrical shapes and their fine finish. Designs can be intricate, but must always be of circular symmetry to fit the process.

For economical production soft metals up to ¼ in. thick, stainless steel up to ⅛ in. and low-carbon steel up to 3/16 in. can be successfully spun at present. The most common metals for industrial spinnings are aluminum, steel, stainless steel, copper, bronze, brass, nickel, tinplate, magnesium, Monel and Inconel.

Tolerances are generally wider than ±0.015 in.—not so precise as stamping or die casting, but better than sand casting. Tolerances of ±0.005 in. can be held, but at higher cost. Quantities of 5000 or more per piece are probably more economically made by stamping, but lots of 20, 100, 500 or even 1000 can be reasonably considered is possible spinnings. The tool costs for spinning are usually negligible in comparison to die or pattern costs for stamping, plastics molding or casting.

Courtesy: Milwaukee Metal Spinning Co.

PROCESS FEATURES | ADVANTAGES, ETC. | TYPICAL PARTS

Impact Extrusions

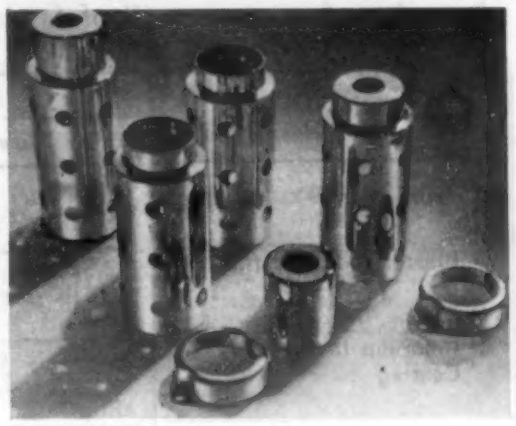
In impact extrusion, suitable dies and presses apply pressure to a cold flat metal blank and cause it to flow through a narrow opening, giving an elongated part of uniform cross section. The opening is the annular orifice between the wall of a stationary-bottom-die cavity and the surface of a punch that presses the blank into the die cavity while the metal is pulled back over the punch.

A process similar to this in many respects is the Hooker extrusion process, in which a cup-shaped blank is used and the metal is extruded *ahead* of the punch through an annular orifice between the punch and die, instead of being pulled back over the punch.

Impact extrusion is in some respects similar to coining and, indeed, coining presses are often used for small impact extrusions. Press operating speeds are high, approximately those of punch presses generally.

Impact extrusions are familiar to many in the form of collapsible tooth paste and shaving cream tubes made of pure tin, tin-lead alloys or aluminum. The process is also extensively used, however, for many industrial products that are characteristically shell- or cup-shaped, and in competition with deep-drawn sheet metal. (See under "Stamping") Relatively shallow articles are cheaper to produce by deep drawing; with some shapes, however, the cylinder length is too long in relation to the diameter for drawing and impact extrusion must be used.

Shells or cups with flat, thick bottoms, diameters ½ to 4 in.; lengths up to 1 ft. and walls from 0.003 to 0.005 in. thick are well suited to the process, especially if part requirements are in the many thousands. (The Hooker process, mentioned in the first column, is extensively used for small arms cartridge cases where it can compete with drawing on runs of 10-15 million pieces). Impact extrusion has been intensively developed for aluminum parts and is also applied to zinc, brass, tin and lead. The Hooker process is chiefly used with brass, copper and aluminum.



Courtesy: Aluminum Co. of America

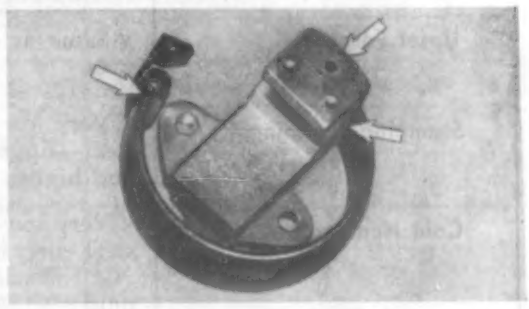
Welded or Brazed Parts

Many complex designs can most economically be manufactured by combining several materials or forms, such as small stampings, screw-machine parts, castings or tubing into one assembly by brazing or welding the components to each other. For this particular purpose brazing and resistance welding are more widely used than arc or gas welding, although the latter are commonly employed to join two simple components (e.g. a tube and a plate or disk) to each other. (Massive assemblies are of course made by welding rather than brazing.)

To obtain the maximum precision the parts are automatically positioned with jigs, fixtures or clamps during joining. Brazing may be done by furnace, torch, dip, salt bath, resistance or induction heating methods and with copper, brazing-brass or silver alloy as the filler metal, depending on the materials to be joined and the type of joint. Joints areas, whether to be welded or brazed, must be carefully cleaned beforehand.

The chief advantage of brazed or welded assemblies in the small part field is that they permit the production of intricately shaped products that might otherwise have to be made using time-consuming machining methods or more expensive materials. Low-carbon steel stampings, tubing, rod and simple machined shapes are the most popular components. In many cases the assembly may be heat treated after joining. The joints are comparable in strength to the parent metals, and brazed assemblies are surprisingly strong and rigid.

Precision is fair, although usually less than could be obtained by machining or die casting. Tool charges are low but labor charges somewhat higher than for many other forms. In comparison with machining, the assembled-unit production method is likely to be faster and usually saves materials; sometimes it permits replacing a critical material like aluminum die castings with assembled steel stampings.



Courtesy: Handy & Harman

Cost, Design and Production Comparisons

Specific comparisons between one fabricating method and another are obviously dangerous without accurate knowledge of the product or part under consideration, including information on the number required, the speed with which they must be produced or delivered, etc. But it *is* possible to classify the various metal-forms or fabricating methods roughly according to their performance in important respects and even to indicate the generally accepted cost, design and production ranges into which each falls.

For this purpose the five pages of tables that follow have been assembled from scattered data already published and from information obtained direct from manufacturers. Each vertical column is concerned with one significant selection-factor that the engineer and designer may recognize when choosing a fabricating method for a particular product; opposite each method the data in the column indicate *roughly* how the method compares with the other methods with respect to the selection-factor in question. The checks and X's are an attempt to indicate which of the methods are outstandingly good (the √'s) and which are weakest (the X's) in each regard. Those not marked at all are "in between"—often relatively good, sometimes not so good, frequently just medium or average.

Readers are cautioned not to use these tables to make arbitrary selections, but to employ them instead as general guides to the choice of two or three methods or forms that might be suitable, and then to carry out a detailed study of the actual relative ability of those few methods to meet the various selection criteria. Even the specific data given in the table are subject to exceptions. The maxima and minima given can be disregarded in unusual cases or where costs or other factors may be ignored. By no means should *close* differences between methods shown in the Table be used as a reason for selecting one of them, for their positions may be reversed when the particular or peculiar circumstances surrounding the part to be made are considered.

For each factor, therefore, the table shows which methods are the leaders and which the trailers. These indications should be "weighted" by the engineer according to his knowledge of the actual importance of the factor in question. A method that shows[1] high raw material cost, but[2] fast production speed and[3] close dimensional accuracy would be a good possibility if all three were important in the product in question, and even more attractive if raw material cost were a minor element, but merely an also-ran if those three factors were all of far less importance than a fourth in which the method is shown to be notoriously weak.

In many cases the final selection will be a compromise—making a concession in one direction to obtain certain needed advantages in another. It is in this wide area that the un-checked and un-Xed items play a leading part in showing which methods although not outstanding are at the same time not dangerous choices either, and the designer may finally choose a form that is largely unmarked in the factors in which he is interested, rather than one that has several √'s counterbalanced by some X's.

Production Methods or Forms	Cost Factors		
	Raw Material Cost	Tool and Die Cost	Optimum Lot Sizes
Sand Casting	√ 1.5¢ per lb. for iron to 20¢ per lb. for magnesium	√ Pattern costs are very low. More machining required than die-formed parts	Wide range 500—10,000
Plaster Mold Casting	12.5¢ per lb. for bronze, 15¢ per lb. for aluminum	Medium — between permanent mold and sand castings	S Short runs 100-2000
Precision Investment Casting	Moderate to high. Often used for special, therefore high-cost alloys	√ Very low. Master mold never wears out.	S Wide range — up to several thousands—but best field is small quantities (10-1000)
Permanent Mold Casting	Most used for medium-cost (Al, Mg, Cu) alloys; sometimes for low-cost (iron and steel)	Moderate—less than die casting and powder metallurgy	L Large quantities—in the thousands
Die Casting	Medium-cost materials (about 10¢ per lb. for zinc or brass, and up)	X Very high. More than other casting methods: Typical dies cost $200 to $700, sometimes up to $3000	L Large quantities—1000 to hundreds of thousands
Drop Forging	√ Can be low, 2¢ per lb. for steel, up to about 20¢ for stainless steel, and higher for some others	X High. Die sets may cost $100—$1000 or more, depending on size, impressions, etc.	L Good for large quantities (10,000 to 100,000) but often satisfactory for small lots
Press Forging	√ Same as drop forgings. For either type aluminum stock may run 25-30¢ per lb.	High, but usually less than drop hammer dies for a given part	Best field is medium to high production lots
Upset Forging	√ Same as drop and press forgings	High, often because of large number of impressions or difficult design	Best field is medium to high production lots
Stamping, Forming	√ Very low—2 or 3¢ per lb. for steel—up to 25¢ for aluminum and higher for some others	X Very high—$400 to $1200 is a common die-cost range for stampings; usually more than die casting	L Large quantity lots—over 10,000—best, but often used for shorter runs
Cold Heading	√ Very low—4 or 5¢ per lb. for steel wire; but also 15¢ for brass, 20¢ for stainless, 26¢ for aluminum	X High—sometimes a few hundred dollars	L Large lots are best—a typically mass-production process
Impact Extruding	X High. Steel cannot generally be used. Aluminum at 20¢ is typical	Moderate—dies often cost under $100. Ordinary punch presses may be used	Wide range. Competes in lots in the millions as well as in thousands
Extruding and Cutting	X High—usually more than 20¢ per lb.	√ Low. Extruded shapes are purchased, and sheared or sawed with simple tools or equipment	Wide range. Useful for very small lots as well as for large
Sectioning Tubing	X High—invariably more than 20¢ per lb. Some much higher	√ Low in many cases. Tubes are cut, often bent and machined with inexpensive tools	Wide range. Good for small lots or for thousands of pieces
Spinning	Low to moderate. Steel (2-3¢ per lb.) up to aluminum sheet (20-23¢) are typical	√ Very low. Forms may cost from $25 to $200	S Small quantities (under 1000); certain shapes and sizes suitable for large quantities however
Screw-machine Work	√ Very low—4-5¢ per lb. for steel (most common material), up to 15-30¢ for brasses and higher for some others	Medium—$50 to $250 is the common tooling-cost range	L Large lots preferred. For automatic machines more than 1000 pieces is essential. Excellent for quantities in the millions
Powder Metallurgy	High. Powders run 13 to 90¢ per lb. for iron, 20 to 25¢ for copper, etc.	X High—usually more than $100, often several hundred dollars per die	L Large lots—over 10,000 pieces—are best to amortize dies. However small runs are sometimes successful
Molding of Plastics	Medium to high—from 10-12¢ per lb. up to about $1.00 per lb.	X Very high. Dies must usually be hardened, and able to resist high pressures. Costs run from $100 to $3000-$4000	L Large lots are best. Seldom economical under 5000 pieces
Welding or Brazing Parts	√ Very low-cost materials (e.g. steel stampings) can be used	Equipment costs are low. Assembly, though, must bear varying tool costs of its components	S Small quantities are best, although simple assemblies of 2 small parts can be cheaply made in quantity

The markings in each column have the following meanings:

- ✓ The best or among the best of the methods in this respect. If the selection factor involved is important for the problem in hand then the method so marked should receive very favorable consideration
- X Seriously limited in the respect indicated. Methods so marked should probably not receive further consideration if the factor involved is of sole or No. 1 importance in the design or manufacture of the product
- L Admirably suited, competitively and economically, to production involving large quantities—10,000 to hundreds of thousands of pieces
- S Peculiarly suited to very small production lots, say up to 1000 parts of one design

Production Methods or Forms	Cost Factors (continued)		
	Direct Labor Costs	Finishing Costs	Scrap Loss
Sand Casting	X High. Men needed to mold, melt, shakeout, clean, etc.	X Machining costs are high. Often must be painted	X Moderately high—chiefly gates, sprues, risers, machining allowance, etc.
Plaster Mold Casting	X High. Many skilled operators	Low—little machining required. Alloys used are corrosion-resistant	Low—chiefly casting scrap
Precision Investment Casting	X High	Low. Often eliminates machining. Good for corrosion-resistant materials	Moderate (sprues, gates, risers, etc.) but remeltable
Permanent Mold Casting	Medium	Low. Small or no machining allowance needed. Applied coatings go on well	Low—mostly reusable casting scrap
Die Casting	Medium to low	Low. Usually no machining needed. Zinc takes plating easily	Low—only gates, risers, etc.
Drop Forging	Medium. Skilled labor required for heating, hammer work, finishing	X Medium. Less than sand castings, but more than metal-mold castings and other forms	Medium. May run from 1% to 25% depending on size and shape
Press Forging	Medium, but lower than drop forging	X Same as drop forgings. All forgings have scaled surfaces, which are usually removed	Medium. Machine finish allowance can be less than drop forgings
Upset Forging	Medium. Lowest of all forging processes	X Medium, but often less than other forging methods. Some holes are pierced in the process	Medium. Scrap loss often less than for other forging processes
Stamping, Forming	Medium to low, depending on part size and shape	Low. Often no finishing, or a merely inexpensive operation, is needed	Moderate. Blanking residue can be minimized by "nesting" and careful sizing of stock
Cold Heading	✓ Low. Process is virtually automatic	Low. Practically no finishing required, except thread rolling or cutting	✓ Very little or no scrap loss
Impact Extruding	✓ Low. Little skilled labor required	✓ Very low. Parts may require no subsequent treatment	Very little waste except blanking scrap
Extruding and Cutting	✓ Very low. Skilled labor not required	Low. Deburring or tumbling sometimes sole finishing operation. Extruded metals are easily machined	✓ Very low. Shapes are in a sense "pre-machined" at the mill, but without waste
Sectioning Tubing	Low in most cases	Low, except where design calls for much machining	✓ Very low. Tubular forms save boring waste
Spinning	X High. Skilled craftsmen are required	Low. Machining seldom needed. Cleaning and painting are common	Moderate. Some waste occurs in shearing blanks from strip or sheet
Screw-machine Work	✓ Very low. Operations are usually automatic. One man watches several machines	Low. Burnishing or cleaning often all that is required	X High, often very high as metal removed in machining is waste
Powder Metallurgy	Low. Some skilled help required, however, and labor is needed for blending, sintering and re-sizing	✓ Very low. Machining is difficult but seldom needed	✓ Very low—virtually no waste metal in the process
Molding of Plastics	✓ Low. Operations are automatic or entirely mechanical	✓ Very low. Frequently no applied finish is required. Tumbling to remove fins is common	Medium to low, depending on process. Flash, gates, overflow are waste. Thermoplastic waste is reusable
Welding or Brazing Parts	Medium to high. For brazing semi-skilled labor is needed	Medium—joints must be cleaned; parts are otherwise finished before assembly.	Low

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L Admirably suited, competitively and economically, to production involving large quantities—10,000 to hundreds of thousands of pieces

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Production Methods or Forms	Production Speeds		Design Factors	
	Getting into Production	Rate of Output	Choice of Materials	Feasible Complexity
Sand Casting	3 days to 15 days for pattern—moderate	25 to 600 or more per hr. (using match plates and high-speed molding machines)	Wide. Ferrous and nonferrous, light and heavy metals cast	√ Very high. Few holes need to be machined
Plaster Mold Casting	Several days to a few weeks	Fast. Up to 1000 per hr. depending on size	X Very narrow—only certain brasses, bronzes and aluminum alloys	√ Very high because mold is destroyed
Precision Investment Casting	√ Very fast—sometimes in a few hours, using a sample part as master mold	X Slow—up to 100 an hour	Wide—includes alloys difficult to machine or forge	√ Very intricate designs are possible
Permanent Mold Casting	Several days to a few weeks	Moderate; up to 100 an hour customary sometimes higher	Wide—aluminum, bronze, iron, steel most-used	Limited by mold and by absence of pressure feeding
Die Casting	Several days to a few weeks	√ High—usual range 100 to 1000 per hr.; sometimes 3000	Narrow—zinc, aluminum, magnesium, brass, tin and lead	Limited only by die, which can be quite complex
Drop Forging	X Slow. One to several weeks required to design part for forging and make dies	Medium—120 per hr. is possible with small parts; 40 per hr. typical rate for large forgings	Medium—ferrous and non-ferrous metals are forgeable with varying ease	Limited by die. Undercuts possible with split dies
Press Forging	X Slow—slightly quicker than drop forging	Medium—slower than drop forging	Similar to drop forging —favors non-ferrous	Limited, even more than drop forging, especially for steel
Upset Forging	X Slow—same as drop forging	Medium—same rates as or faster than drop forging	Medium—many ferrous and nonferrous alloys	X Limited to "cylindrical" shapes and certain dimensional ratios.
Stamping, Forming	X Slow. Die design and production may take several days to weeks	√ Very high—sometimes up to 3000 per hr.	Wide—includes all workable sheet metals	Limited to shapes formed from sheet metal. Many restrictive design-rules
Cold Heading	Fair. Dies can be obtained in a few days	√ Very high—4800 per hr. is common, 20,000 per hr. possible	Narrow. Confined to ductile metals, preferably steel	Very limited; less flexibility than forging
Impact Extruding	Fair. Dies can be obtained in a few days	√ Very high—small parts can be produced faster than 2,000 per hr.	Narrow. Aluminum, copper alloys, soft metals best	X Limited generally to shell-like shapes and derivatives
Extruding and Cutting	Quickly, after shapes are in stock. If shape is "special" the mill may take some time to deliver	High—1000 small parts per hr. possible on automatic lathes	Narrow. Copper alloys (including free-machining stock), aluminum, magnesium popular.	Can be of complex section, but section must be uniform along length
Sectioning Tubing	√ Quickly, and delivery of standard round or rectangular tubing is fast	High. Cutting can be done automatically on fast machines	Wide. Steels, stainless steels, all ductile nonferrous metals available	X Limited by tubular base of raw material
Spinning	Quickly. Forms can be made in a few days. Method is amenable to fast redesign	X Slow—12 to 30 per hr. covers many typical jobs	Wide. Many sheet metals, including stainless steel, nickel alloys, light metals, etc. are spinnable	X Limited to cylindrical, circular or concentric shapes
Screw-machine Work	Moderately fast. Tool engineering plus set-up may take a few days	√ Very high, up to 3000-4000 per hr. for smallest parts	√ Very wide, with a few materials (steel, brass, aluminum and magnesium) most used.	Limited to rotational shapes, although cross holes and undercuts are easily made
Powder Metallurgy	Medium. Dies must be very carefully designed and made of hard-to-machine materials. Set-up time is 1-30 hrs.	√ High—1800 per hr. is not uncommon. In rare cases output may be several thousand per hr.	X Very narrow for machine parts (iron, iron-copper, copper, bronze, brass, steel)	X Limited by die, by poor flow of powders, and by difficulty of transmitting pressures through great depths of powder.
Molding of Plastics	X Slow. 3-6 weeks often required for dies	Medium—500 parts per hr. is fast; 300 shots per hr. about the max. 20-60 shots per hr. an average	Very many resins can be used, and hundreds of molding compounds	Limited by die, but some side coring, etc. is possible
Welding or Brazing Parts	Can be fast, once design and method are determined	X Varies over a wide range, but on the medium to low side	√ Very wide. Dissimilar metals can be assembled into one product	√ Very complex and intricate.

Production Methods or Forms	Design Factors (continued)			
	Maximum Size	Minimum Size	Precision and Tolerances	Mechanical Properties
Sand Casting	√ Largest sizes are possible	1/8 in. the practical minimum section thickness	X Low. ±1/32 in., commercial tolerances	Fair
Plaster Mold Casting	Up to 15 lbs.	√ Very thin—down to 0.032 in. for smallest parts	Good. ±0.005—0.010 in.	Fair
Precision Investment Casting	X May be high. Best field though, is under 2 lbs.	√ Very small. Sections may be 0.032 in.	√ High. ±0.002 to 0.005 in. common; closer, possible	Good
Permanent Mold Casting	Practical limit is under 50 lbs. (aluminum). Centrifugal castings may be much heavier than static	About 1 oz. Sections as thin as 0.1 in. often cast; 0.060 in. rarely	High. ±0.0015 to 0.010 in.	Fair; good for centrifugal castings
Die Casting	About 35 lbs. for zinc, 18-20 lbs. for light metals	√ Tiny—fractions of an oz. Sections may be 0.012—0.015 in. for zinc, 0.035 to 0.050 for other alloys	√ High. ±0.001 to 0.003 in. regularly met	Fair to good; adequate for many structural uses
Drop Forging	√ Very large—can be way over 100 lbs. Board hammer max. is 15 lbs.; steam hammer good for larger sizes	Small—fractions of an ounce. Board drop hammer used for smallest drop forgings	Medium—±0.010 to ±0.030 in. tolerances are normal. ±0.004 or better possible by coining at extra cost	√ Very high
Press Forging	25-30 lbs. the practical maximum, although larger parts are in production	Small—fractions of an ounce; usually preferred over drop forging for smallest parts	Medium—somewhat better than drop forging	√ Very high
Upset Forging	√ Medium to large—9 in. bar about the largest size; weights may be hundreds of lbs.	Small. None of the forging methods approaches die casting or stamping in thinness of sections	Medium—similar to press forging	√ Very high
Stamping, Forming	√ Almost unlimited. Good method for very large parts, design permitting	√ Tiny. Sections as thin as 0.003 to 0.005 in. possible	√ Very high. ±0.001 in. is common, and closer tolerances are possible on smallest parts	High, sometimes very high
Cold Heading	X Small—7 in. long x ½ in. dia. is usual maximum	Small—1/8 in. dia. parts are the smallest usually made	High. ±0.002 in. possible; ±0.010 in. is common	√ Very high. Parts are often heat treated
Impact Extruding	Large—press capacity chief limitation. Common large size is 4 in. dia. x 12 in. length	√ Small—fractions of an ounce. Walls may be as thin as 0.003 in.	√ Very high. Tolerances closer than ±0.001 in. are common	High. Parts are cold-worked. Aluminum alloys can be heat-treated
Extruding and Cutting	Medium—8 or 10 in. dia. is the usual max. Lengths may be very great	Very small. 1/16 in. gages possible with aluminum and magnesium.	Fair—±0.007 to 0.020 common on widths for aluminum and ±0.005 and wider for copper alloys	Good. Aluminum and magnesium alloys can be heat-treated. Strong brasses and bronzes used
Sectioning Tubing	Large—usually 4-6 in. o.d. max., but larger sizes (up to 12 in. o.d.) can be purchased in carbon steels	√ Very small—down to 0.012 in. o.d. for stainless; 1/16 in. is a common min.	Good—very small sizes can be held to ±0.002 in; larger sizes ±0.004 to 0.025	√ Very good. Cold working provides extra strength. Strong alloys are available
Spinning	√ Very large—over 90 in dia. Max. gages are about ¼ in. for soft metals down to 1/8 in. for stainless	Spinnings ¼ in. dia. in gages less than 0.040 in. are made	Fair—±0.015 to 0.060 are commercial tolerances. ±0.005 in. available at extra cost	√ Good. Materials may be strong and the process cold works them
Screw-machine Work	X Medium—up to 2-¾ in. dia. x 6 in. long, but usually smaller	√ Very small—often under 1/16 in. dia. and weighing fractions of an oz.	√ Very high. ±0.0005 to 0.001 in. possible; ±0.001 to 0.003 customary	√ Very high. Strongest materials are commonly machined
Powder Metallurgy	Small parts—up to 4 sq. in. section—are best, but bearings as large as 18. in. dia. have been made	√ Very small. Parts smaller than 1/16 in. dia. or width can be made	√ Very high. ±0.0005 to 0.001 in. available by sizing; ±0.001-0.005 common	X Medium to low. Impact values are low, wear resistance high, tensiles higher than formerly
Molding of Plastics	Small parts are best—usually under 2 lbs. Practical limit is 18 in. x 12 in. with 5/16 in. wall, although larger parts are made	√ Very small—1/32 in. thickness is a common minimum	√ High. ±0.005 in. are commercial tolerances. "Close" tolerances are ±0.002 in. Transfer molding is most precise	X Very low. Invariably much lower than metal parts made by any other method
Welding or Brazing Parts	√ Structures of unlimited size are possible	Usually not very small. Thin sections can be combined with thick in the same design, however	X Medium. Depends on precision of component forms; joints are seldom closer than ±0.020	Good; depends on properties of components

Production Methods or Forms	Design Factors (continued)				
	Weight (Spec. Gravity)	Corrosion Resistance	Structural Effects	Surface Smoothness	Surface Detail
Sand Casting	1.8 magnesium to 7.3 (iron)	Often needs protection. Brass and bronze very high. Magnesium low.	Good bearing structure	X Low	Fair
Plaster Mold Casting	2.7 for aluminum to 7.5 for bronze	Good	None	High	√ Very good
Precision Investment Casting	X Usually applied to heavier metals	√ Very high. Certain corrosion-resistant alloys especially amenable	None	Good—among the best	√ Accurate reproduction of surface detail possible
Permanent Mold Casting	Applicable to light weight metals	Bronzes, aluminum alloys, other corrosion materials can be used	Centrifugal castings have high strength and density	Good — often obviates finishing	Fair — better if centrifugal
Die Casting	Can be very light (Sp. gr. of Mg alloys is 1.81)	Brass good, zinc and aluminum fair; magnesium needs protection	Inserts of other metals may be incorporated	Good. Better than non-metal-mold castings	√ Very good
Drop Forging	Light weight and heavy metals are forgeable	Several corrosion-resistant alloys are forgeable	"Grain flow" of parts provides extra toughness	Medium — better than sand castings	Medium — some detail reproducible
Press Forging	Used for lightweight and heavy metals; popular for aluminum	Aluminum and brasses are typical corrosion-resistant press-forged materials	Hot-worked structure a mechanical advantage	Medium—same as drop forgings	Medium—same as drop forgings
Upset Forging	Used mostly for heavy metals, but occasionally for light	Corrosion-resistant alloys are forged by this method	"Grain-flow" a useful structural feature	Medium—same as drop forgings	Medium—same as drop forgings
Stamping, Forming	Very low. Thin sections, strong materials, often light metals confer low weight	High. The most resistant metals are easily stamped	None	√ Very high	Fair
Cold Heading	Light metals are readily headed	Some corrosion-resistant metals (especially brass, Monel and stainless) are cold headed	Grain flow developed is an asset	High — approaches screw machine parts	Fair
Impact Extruding	Very light. Aluminum is a popular material	High. Aluminum, tin, brass, lead are all resistant	None	Very high	Good, if required
Extruding and Cutting	Minimum-weight parts can be produced this way	Good to fair (brass to magnesium). Stainless extrusions not available	None	Good	Only as part of extruded contour
Sectioning Tubing	Tubing is basically a lightweight form. Light metals also available	Very good. The most corrosion-resistant common materials (stainless, brass, etc.) can be had	None	Very good	None possible by this process
Spinning	Very light. Aluminum is the most spinnable metal	Good. Aluminum, copper and stainless steel can be used	None	√ Very good. Surface finish often beautiful and spun shapes attractive	None possible by this process
Screw-machine Work	Very light. Lightest materials (magnesium and plastics) are most machinable	Very high. Brasses and free-machining stainless steel commonly processed	None	√ Excellent. Surfaces are smooth and lustrous	Good. Knurling and fine serrations readily made
Powder Metallurgy	On the heavy side. Techniques for aluminum not generally perfected	X Medium. Copper alloys the only corrosion resistant powder materials widely used for machine parts	√ Many special structures — regulated porosity, duplex materials, incorporation of nonmetals are possible	Fair. Surface structure is frequently porous	Good. Some detail can be readily registered on suitable surfaces
Molding of Plastics	√ Very light. Most plastics are lighter than the lightest metal	√ Very high. Surfaces are seldom affected by the atmosphere; inert to many chemicals, too	Inserts, metal-inlays and various combinations with fillers, etc. are possible	√ Excellent. Beautiful and novel colors and effects are also available	√ Good. Markings, etc. readily reproduced, especially if depressed rather than raised
Welding or Brazing Parts	Very lightweight structures are possible	Corrosion-resistant materials can be handled readily	Powder metallurgy parts or other special-structure components can be joined	Fair — no better nor worse than component parts	None possible by the joining process itself

Materials and Corresponding Forms for Small Parts

Material	*Physical Properties*				*Atmospheric Corrosion Resistance*	*Forms in which commonly used for small parts**
	Melting Points °F.	*Spec. Gravity*	*Tensile Strength, p.s.i.*	*Yield Strength p.s.i.*		
Low-carbon steel and iron	2750-2800	7.8-7.9	50,000-120,000	30,000-90,000	Poor	1, 6, 7, 8, 9, 10, 13, 14, 15, 16, 18
High-carbon steels	2600-2750	About 7.8	100,000-200,000	75,000-175,000	Poor	1, 3, 9, 10, 13, 15, 18
Engineering alloy steels	2500-2750	7.8-8.8	80,000-250,000	50,000-210,000	Fair	1, 3, 6, 7, 8, 9, 10, 13, 14, 15, 18
Tool and die steels	2600-2800	7.5-10	100,000-250,000	80,000-200,000	Good	1, 3, 6, 13, 18
Tungsten carbide	Cobalt melts 2700	14-15	125,000-400,000 transverse rupture str.		Good	16, 18
Stainless steels	2500-2800	7.4-8.0	100,000-220,000	50,000-125,000	Excellent	1, 3, 6, 7, 8, 9, 10, 13, 14, 15, 18
Tinplate	Tin melts 450	About 8	50,000-60,000	25,000-30,000	Excellent	9, 13, 14, 18
Iron, cast and malleable	2100-2400	About 7	25,000-120,000	Up to 60,000	Fair	1, 4, 9, 16, 18
Copper	1980	8.9	23,000-52,000	14,000-50,000	Good	1, 6, 7, 8, 9, 11, 12, 13, 14, 16, 18
Bronzes	1800-1950	7-9	40,000-200,000	20,000-175,000	Very good	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18
Porous bronze	Above 1500	5.8-6.7	10,000-20,000	8,000-15,000 (compression)	Very good	16, 18
Brasses	1720-1950	8.4-8.8	30,000-90,000	15,000-50,000	Very good	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16
Tungsten-copper	Copper melts at 2000	12-16	60,000-175,000	.....	Good	16, 18
Nickel-base alloys	2200-2600	8.3-8.9	60,000-100,000	30,000-80,000	Excellent	1, 3, 6, 7, 8, 9, 10, 13, 14, 15, 18
Cobalt-chromium, etc. alloys	2200-2400	8.4-8.6	45,000-110,000	.....	Excellent	1, 3, 18
Noble metals (including silver)	1750-3600	10-21.5	23,000-150,000	12,000-80,000	Excellent	3, 9, 10, 11, 13, 14, 15, 16, 18
Zinc and its alloys	715-785	6.6-7.1	15,000-45,000	10,000-25,000	Good	5, 11, 14, 18
Lead and its alloys	300-625	10.5-11.5	2,000-12,000	1,000-10,000	Good	5, 11, 12, 13, 18
Tin alloys	360-470	7.3-7.8	2,000-15,000	1,300-9,800	Very good	5, 11, 14, 18
Aluminum and its alloys	940-1225	2.6-2.9	13,000-72,000	5,000-62,000	Very good	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18
Magnesium alloys	815-1200	1.74-1.9	13,000-65,000	3,000-50,000	Fair	1, 4, 5, 6, 7, 8, 11, 12, 13, 15, 18
Plastics	Working temps. below 475°	1.25-2.09	3,000-15,000	.....	Excellent	17

* Metal-Forms:

1 Sand castings
2 Plaster mold castings
3 Precision castings
4 Permanent mold castings
5 Die castings
6 Drop forgings
7 Press forgings
8 Upset forgings
9 Stampings, formed parts
10 Cold headed parts
11 Impact extrusions
12 Cut extrusions
13 Processed tubing
14 Spinnings
15 Screw machine parts
16 Powder metal parts
17 Molded plastics
18 Welded or brazed assemblies

Typical Applications to Design Situations

A few typical design situations and the metal-forms or production methods that could properly be considered for each of them are given below. Generally speaking no single preferences can be indicated here for each case, since the choice can be made only by the designer after a detailed study of all the factors concerned. The data that follow are useful in the preliminary weeding-out stage, but should be considered merely as a few over-simplified samples of the vast number of part shapes and design situations that could be discussed.

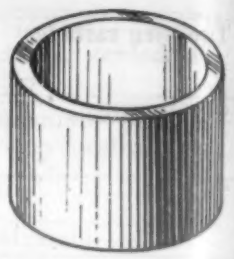
CASE 1. *Small part (less than 2 oz.) of irregular non-symmetrical cross section, tapered along its length, with a flange at the large end. Required in more than 10,000 lots. Tolerances are ±0.003 in. Part must be minimum cost, non-rusting, and have moderate service strength.*

The general shape described can be made by any casting or forging process, cold heading, screw-machine work, powder metallurgy, molding of plastics or brazing the flange onto the shank. The large number required, and the close tolerance and minimum-cost stipulations, however, point to *die casting, cold heading, screw-machining, powder metallurgy* and *molded plastics* as broadly the best possibilities.

In addition to these, *die forging* should be considered if quantities are enormous and *precision investment casting* if the material required happens to be of an unmachinable or unworkable nature.

CASE 2. *Thin-walled cup-shaped part less than 2 in. long and less than 1 in. dia., with straight (cylindrical) sides. It is required to be rigid and to be dimensionally accurate to ±0.007 in. Part requirements are in the millions and at a fast rate; mechanical quality and corrosion-resistance specifications are stiff. Costs are important but not the No. 1 factor.*

Generally speaking, the most likely metal-forms are (a) for thicker walls and shallow depths—*brass or bronze permanent mold castings, brass die castings, steel or brass press forgings, steel stampings;* (b) for thinner walls and greater depth—*stamped and drawn* parts, or *impact extrusions.* Methods based on the use of steel would require subsequent protective finishing. *Zinc alloy die castings* would definitely enter the picture if emphasis on low-cost became greater than that on mechanical properties.

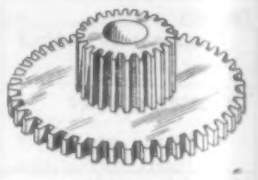


CASE 3. *Straight-sided hollow cylinders of 1 in. o.d. at both ends, annular section relatively large, length (or height) ranging from 1 in. down to ⅛ in. Requirements are 200,000, tolerances ±0.002 in. (except in the taller pieces where the height tolerances may be ±0.005 in.). Mechanical quality must be good and costs kept as low as possible.*

The general shape indicated may best be produced in the taller form by *sand casting* and then machining to accurate dimensions, *die casting, forging, cutting tubing, machining bar stock, powder metallurgy* or *molding plastics;* the flat forms by *die casting, stamping, cutting tubing, powder metallurgy* or *molding plastics.* The quantity, cost and mechanical-property stipulations would indicate either cut tubing or powder metallurgy parts for the tall varieties and stamping or powder metallurgy for the flat.

CASE 4. *Gears or thick disks (1 oz. to 2 lbs.) with bossed hubs, center holes, and external teeth on peripheries. Tolerances are ±0.003 in. up to ±0.010 in., part requirements in the tens of thousands, mechanical quality needed not the very highest.*

Plaster mold casting, precision casting, permanent mold casting, die casting, drop forging, screw machine work, powder metallurgy, molding of plastics and *brazing* the flat disk and hub together are all feasible methods for parts like this. *Extruded shapes* may be separately cut for the disk and the hub and later joined. As mechanical requirements tighten the field would be narrowed by the elimination of plastics and perhaps of powder metallurgy parts and some types of die castings. Actual lot sizes and the depths and pitch of the gear teeth would further influence the extent of competition among forging, screw machining, powder metallurgy and the casting processes for such work as this.



CASE 5. *Hollow parts between 1 in. and 10 in. in dia., basically semispherical in shape with thin sections and perhaps flares, flanges, steps, center holes, etc. present. Tolerances are ±0.010 to 0.020, lightness and rigidity required. Assume that costs are the No. 1 factor only with the smallest sizes, which are required in quantities of over 100,000; larger sizes are needed only between 1000 and 5000 pieces.*

Shapes like this can best be made by *sand or permanent mold casting* (if walls are thick), *plaster mold casting, die casting, press forging, stamping* or *spinning.* Actually the fast-production, large quantity, low cost requirements of the smaller sizes would probably favor die casting or stamping and for the low-production larger sizes spinning would appear to be the ideal method. If however, the stiffness required were greater than these provided sand casting might be a likely possibility.

Bibliography

Information for this Manual was obtained from a large number of sources, including several published works. Among those relied on most heavily (and virtually essential to the engineer in going beyond the merely preliminary-choice phases covered here) are the following:

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NUMBER 51

July, 1944

The National Emergency Steels

(Revised May 26, 1944)

In this latest revision of the NE steel composition limits, the 8700 series has been restored in a wider variety of carbon ranges. A new series, the 9700 series, has been established having hardenability characteristics similar to those of the 4000 series. A new series, the 9800 series, has been established having hardenability characteristics about half way between those of the 8700 series and those of the 4300 series, in the thorough-hardening carbon ranges. A new series, the 9900 series, has been established in the low carbon ranges, designed especially for carburizing and having hardenability characteristics similar to or slightly in excess of the 8700 series.

Classification	Composition						
	Designation	C	Mn	Si	Ni	Cr	Mo
Carbon-Manganese	NE 1330	0.28/0.33	1.60/1.90	0.20/0.35	—	—	—
	NE 1335	0.33/0.38	1.60/1.90	0.20/0.35	—	—	—
	NE 1340	0.38/0.43	1.60/1.90	0.20/0.35	—	—	—
	NE 1345	0.43/0.48	1.60/1.90	0.20/0.35	—	—	—
	NE 1350	0.48/0.53	1.60/1.90	0.20/0.35	—	—	—
Nickel-Chromium-Molybdenum	NE 8612	0.10/0.15	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8615	0.13/0.18	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8617	0.15/0.20	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8620	0.18/0.23	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8622	0.20/0.25	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8625	0.23/0.28	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8627	0.25/0.30	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8630	0.28/0.33	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8632	0.30/0.35	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8635	0.33/0.38	0.75/1.00	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8637	0.35/0.40	0.75/1.00	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8640	0.38/0.43	0.75/1.00	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8642	0.40/0.45	0.75/1.00	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8645	0.43/0.48	0.75/1.00	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8647	0.45/0.50	0.75/1.00	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8650	0.48/0.53	0.75/1.00	0.20/0.35	0.40/0.70	0.40/0.60	0.15/0.25
	NE 8712	0.10/0.15	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8715	0.13/0.18	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8717	0.15/0.20	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8720	0.18/0.23	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8722	0.20/0.25	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8725	0.23/0.28	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8727	0.25/0.30	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8730	0.28/0.33	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8732	0.30/0.35	0.70/0.90	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8735	0.33/0.38	0.75/1.00	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8737	0.35/0.40	0.75/1.00	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8740	0.38/0.43	0.75/1.00	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8742	0.40/0.45	0.75/1.00	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8745	0.43/0.48	0.75/1.00	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8747	0.45/0.50	0.75/1.00	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 8750	0.48/0.53	0.75/1.00	0.20/0.35	0.40/0.70	0.40/0.60	0.20/0.30
	NE 9415	0.13/0.18	0.80/1.10	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9417	0.15/0.20	0.80/1.10	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9420	0.18/0.23	0.80/1.10	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9422	0.20/0.25	0.80/1.10	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9425	0.23/0.28	0.90/1.20	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9427	0.25/0.30	0.90/1.20	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9430	0.28/0.33	0.90/1.20	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9432	0.30/0.35	0.90/1.20	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9435	0.33/0.38	0.90/1.20	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9437	0.35/0.40	0.90/1.20	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9440	0.38/0.43	0.90/1.20	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9442	0.40/0.45	1.00/1.30	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9445	0.43/0.48	1.00/1.30	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9447	0.45/0.50	1.20/1.50	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9450	0.48/0.53	1.20/1.50	0.20/0.35	0.30/0.60	0.30/0.50	0.08/0.15
	NE 9722	0.20/0.25	0.50/0.80	0.20/0.35	0.40/0.70	0.10/0.25	0.15/0.25
	NE 9727	0.25/0.30	0.50/0.80	0.20/0.35	0.40/0.70	0.10/0.25	0.15/0.25
	NE 9732	0.30/0.35	0.50/0.80	0.20/0.35	0.40/0.70	0.10/0.25	0.15/0.25
	NE 9737	0.35/0.40	0.50/0.80	0.20/0.35	0.40/0.70	0.10/0.25	0.15/0.25
	NE 9742	0.40/0.45	0.50/0.80	0.20/0.35	0.40/0.70	0.10/0.25	0.15/0.25
	NE 9745	0.43/0.48	0.50/0.80	0.20/0.35	0.40/0.70	0.10/0.25	0.15/0.25
	NE 9747	0.45/0.50	0.50/0.80	0.20/0.35	0.40/0.70	0.10/0.25	0.15/0.25
	NE 9750	0.48/0.53	0.50/0.80	0.20/0.35	0.40/0.70	0.10/0.25	0.15/0.25
	NE 9763	0.60/0.67	0.50/0.80	0.20/0.35	0.40/0.70	0.10/0.25	0.15/0.25
	NE 9768	0.64/0.72	0.50/0.80	0.20/0.35	0.40/0.70	0.10/0.25	0.15/0.25
	NE 9830	0.28/0.33	0.70/0.90	0.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30
	NE 9832	0.30/0.35	0.70/0.90	0.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30
	NE 9835	0.33/0.38	0.70/0.90	0.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30
	NE 9837	0.35/0.40	0.70/0.90	0.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30
	NE 9840	0.38/0.43	0.70/0.90	0.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30
	NE 9842	0.40/0.45	0.70/0.90	0.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30
	NE 9845	0.43/0.48	0.70/0.90	0.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30
	NE 9847	0.45/0.50	0.70/0.90	0.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30
	NE 9850	0.48/0.53	0.70/0.90	0.20/0.35	0.85/1.15	0.70/0.90	0.20/0.30
	NE 9912	0.10/0.15	0.50/0.70	0.20/0.35	1.00/1.30	0.40/0.60	0.20/0.30
	NE 9915	0.13/0.18	0.50/0.70	0.20/0.35	1.00/1.30	0.40/0.60	0.20/0.30
	NE 9917	0.15/0.20	0.50/0.70	0.20/0.35	1.00/1.30	0.40/0.60	0.20/0.30
	NE 9920	0.18/0.23	0.50/0.70	0.20/0.35	1.00/1.30	0.40/0.60	0.20/0.30
	NE 9922	0.20/0.25	0.50/0.70	0.20/0.35	1.00/1.30	0.40/0.60	0.20/0.30
	NE 9925	0.23/0.28	0.50/0.70	0.20/0.35	1.00/1.30	0.40/0.60	0.20/0.30
Silicon-Manganese	NE 9255	0.50/0.60	0.70/0.95	1.80/2.20	—	—	—
	NE 9260	0.55/0.65	0.70/1.00	1.80/2.20	—	—	—
	NE 9261	0.55/0.65	0.70/1.00	1.80/2.20	—	0.10/0.25	—
	NE 9262	0.55/0.65	0.70/1.00	1.80/2.20	—	0.25/0.40	—
Carbon-Chromium	NE 52100A	0.95/1.10	0.25/0.45	0.20/0.35	1.30/1.60	0.35 max.	0.08 max.
	NE 52100B	0.95/1.10	0.25/0.45	0.20/0.35	0.90/1.15	0.35 max.	0.08 max.
	NE 52100C	0.95/1.10	0.25/0.45	0.20/0.35	0.40/0.60	0.35 max.	0.08 max.

Photo by U. S. Army Signal Corps.

B&W Mechanical Tubing is being used by the Armed Forces for gun mounts, tank and tractor parts, rockets, burster shells, ammunition containers, fragmentation bombs, range finders and CO_2 bottles.

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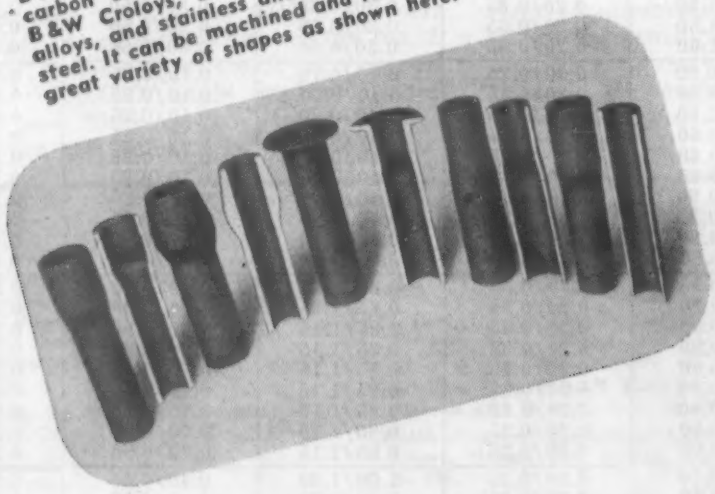
B&W Seamless Tubing can be furnished in carbon steels, B&W Croloys, carbon molybdenum steel, alloys, and stainless and corrosion-resistant steel. It can be machined and formed into a great variety of shapes as shown here.



Anti-aircraft gunners depend on the accuracy of this range finder to get them "on target." Many tube users are depending on Babcock & Wilcox to get them "on target" when it comes to selecting the tubing best suited to their mechanical needs. They know that from B&W they can always be certain of getting *unbiased* recommendations on their tube problems. That's because B&W furnishes tubing for practically any mechanical requirement, and is therefore in a position to match tubing to individual jobs without prejudice toward any type.

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TA-1296

METALS and ALLOYS

Engineering File Facts

NUMBER 52
July, 1944

PROCESSES AND PROCEDURES
Inspection

Glass Gages

Born of the necessity for conserving tool steels, glass gages have shown themselves for certain uses to be acceptable substitutes for their steel predecessors. They have not, in general, superceded steel gages, but there are some very interesting applications, as noted below.

Types of Glass Gages Now in Use

Sets of glass gage blanks are being manufactured in conformance with the standards set up in Commercial Standard CS 8-41. The following types of glass gages have proven successful in ordnance work:

(1) Plug gages ¼ in. or more in diam. (plain plugs, and go and no-go double end plugs)

(2) Ring gages (plain, go and no-go, and combination and snap gages)

(3) Snap gages

(4) Profile and position gages

Characteristics and Physical Properties

The fragility of glass is as much an advantage as a disadvantage. If a glass gage is dropped, it may chip or break; in either case the damage is obvious, while a steel gage similarly mishandled would not indicate its damage but would have to be very carefully checked by a gage inspector (for steel gages may be sprung or bent by dropping). Humidity, common acids, perspiration, etc., will not rust or corrode glass gages. Likewise, gages made of glass need not be greased for rust protection when shipped or stored.

The common types of glasses used for the making of plug and ring gages include lime glass, borosilicate (Pyrex) and light flint glass. Some of the physical properties of these glasses are tabulated in Table 1, along with those of two steels for comparison.

As may be seen in Table 1, the glasses do not conduct either heat or electricity. This means that the glass gages have greater dimensional stability and variations in room temperature, or the influence of heat from the user's hands will not change their size nearly as much as in the case of steel gages.

Not only are the superior dimensional stability and favorable hardness qualities of glass gages important, but the wear resistance of these materials is in some ways superior to that of hardened steel. For example, in gaging drawn brass cartridge cases, a glass plug gage was used to check 163,000 cases; it showed a total wear of 0.00005 in. (or a wear of 0.000031 in. per 100,000 cases); 800,000 of the same type of cartridge case were checked with a hardened steel plug gage with a resulting wear of 0.0007 in. (or 0.000088 in. per 100,000 cases). This means that the glass gage will check 2.8 times the number of cases as the steel one before its size is rendered inaccurate by wear.

The wear resistance of glass gages is also indicated in other ways. Scratches on steel plug gages raise burrs that cause the gage to pass oversized parts; in the case of glass gages, scratching does not raise burrs, hence the size is not affected. And there is no seizing or galling (as there is with steel gages) when checking copper or brass parts. This not only reduces the wear on the gage, but speeds up inspection.

Finishing Techniques

For glass gages to be as useful and accurate as possible, plug and ring gages must possess the following qualifications: (1) The gaging surfaces must be true cylinders (without taper or eccentricity); and (2) these surfaces must have the best surface finish obtainable.

In order that the gaging surface be a true cylinder, the grinding operation must be performed on a precision machine where vibration is a minimum; vibration will affect both the quality and accuracy of the ground surface. Rough and finish grinding are sufficient to bring the gage from a rough blank to a highly accurate, smoothly finished instrument. During these grinding operations, it is essential that the work be flooded with coolant for, unless it is adequately cooled, the glass will develop high internal stresses that may cause it to spall or crack, or it may contain enough stresses to cause it to shatter under the slightest impact. Suggested conditions and sequence of operations for rough and finish grinding the gaging surfaces of a go and no-go glass ring gage are listed. (The corresponding procedure for a plug gage would be very similar).

Rough grinding the ID* of a glass ring gage:

Type of machine ——— Precision internal grinder
Wheel speed ——— 12,000 r.p.m.
Type of wheel ——— A soft, fine grain vitrified bond silicon carbide wheel (¾ in. in diam.)
Condition of wheel ——— Diamond trued and dressed
Work speed ——— 225 r.p.m.
Table traverse ——— 50 in. per min.
Feed per pass ——— 0.0005 in.
Total feed ——— 0.030 in.
Surface finish ——— 6 to 8 microinches, r.m.s.

Finish grinding the ID of a glass ring gage:

(Use the same machine, work and wheel speeds as above)
Type of wheel ——— A soft, very fine (flour) and widely spaced grain, shellac bonded, silicon carbide wheel (¾ in. in diam).
Condition of wheel ——— Diamond dressed and then glazed over with a piece of hardened steel
Table traverse ——— 20 in. per min.
Feed per pass ——— 0.001 in.
Total feed ——— 0.005 in.
Surface finish ——— 1 to 1¼ microinches, r.m.s

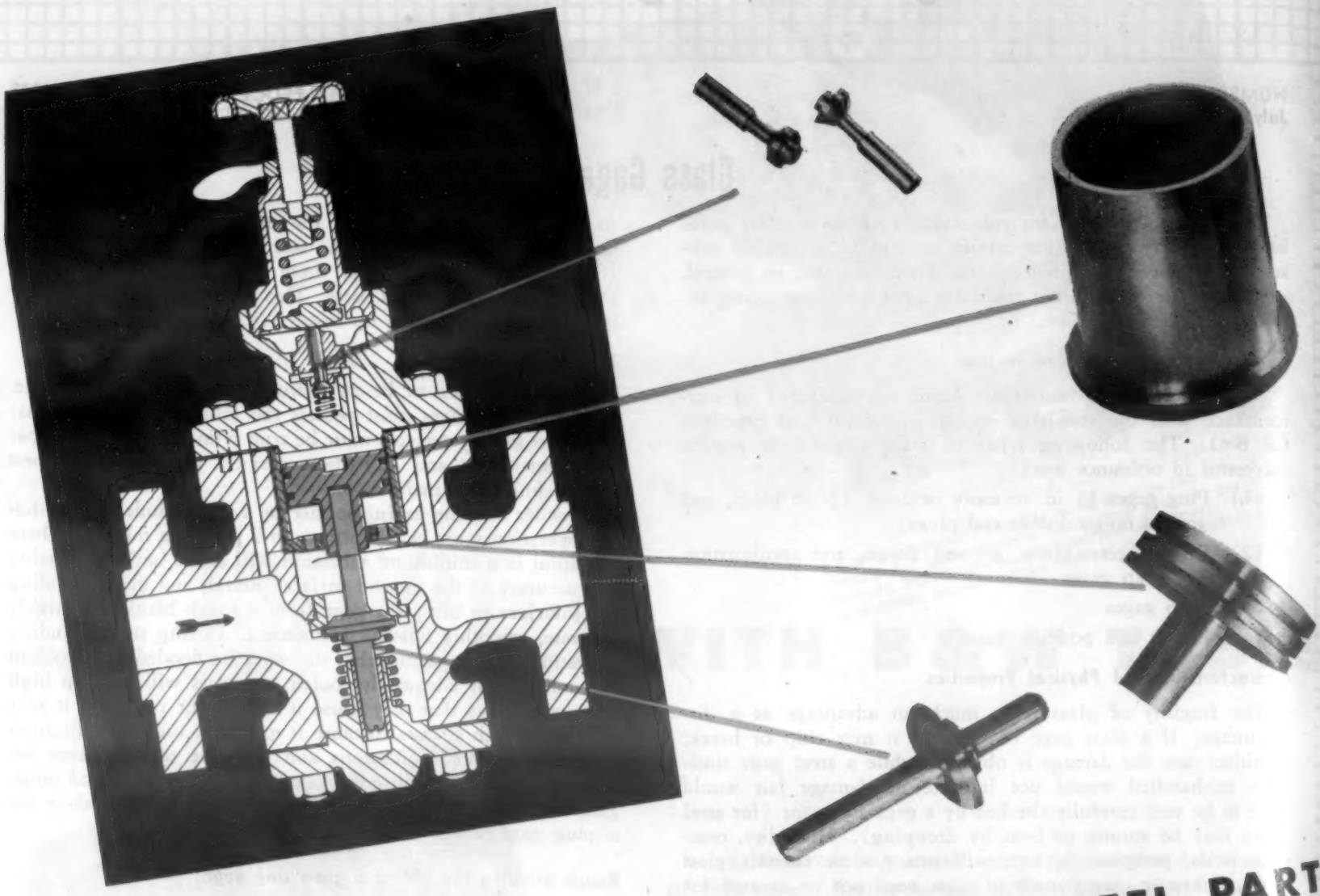
* Approximately 1 in. ID.

In cases where greater accuracy is required than is obtainable by grinding, the gage can be chucked in a speed lathe and the ID lapped, using an expanding zinc or pewter lap and an abrasive mixture of optical flour in light machine oil. After this lapping to the proper dimension, the final finishing is accomplished by using a hard felt lap saturated with a rouge and water mixture.

TABLE I

Type of Material	*Ability to Conduct Heat*	*Thermal Coefficient of Expansion (per °F.)*	*Density (lb./in.³)*	*Electrical and Magnetic Properties*
Pyrex glass	Poor	0.000002	(about 0.2)	Non-magnetic and an insulator
Light flint glass	"	0.000005	(")	
High-speed steel	Excellent	0.000009	0.31	Magnetic and a good conductor
1% carbon tool steel	"	0.000007	0.28	

Prepared by Robert S. Burpo, Jr.



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Take a look at these working parts of a famous Leslie Pressure Reducing Valve and consider some of the super-hazards which try to destroy their service life:

Dry, sliding friction under high temperatures rasps away at the surface of cylinder lining and piston wall . . . high pressure steam at 600 psi. develops pressure-cutting velocities to ruin valve seats . . . heat—750° of it—provides warping torture for valve stems and close fitting surfaces!

All in all it adds up to quite an order . . . but it's another good example of a difficult problem licked by the use of **stainless steel parts hardened by the *INDUSTRIAL SURFACE HARDENING PROCESS.**

For detailed information on how to increase the service life of **your** stainless steel valve, pump or instrument parts, write to us direct.

*** THE INDUSTRIAL SURFACE HARDENING PROCESS provides stainless steel with a "glass-hard" (91 to 97 Rockwell 15-N) surface without appreciable loss of the inherent corrosion resisting qualities of the stainless.**

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THE INDUSTRIAL PROCESS • FOR SURFACE HARDENING STAINLESS STEEL PARTS

METALS and ALLOYS

Engineering File Facts

NUMBER 53
July, 1944

PROCESSES AND PROCEDURES
Cleaning

Metal Cleaning—The Alkaline Processes

Name of Process	Type of Work Handled	Mechanism of Cleaning, Cleaning Agent, Bath Characteristics, etc.	Economic Considerations and Types of Equipment Used
Alkaline Cleaning	Iron and steel parts requiring the removal of greases, oils, and dirt. Almost any size workpiece can be cleaned by this process if the proper type of equipment is employed. As a chemically clean surface is obtained with this cleaner, it is often used as the final cleaning operation prior to electroplating.	The cleaning agent is a water solution of an alkali or of a commercial alkaline cleaner; this solution will emulsify most oils and greases. These alkaline cleaners are sold as a dry powder and this powder usually includes several agents: a source of alkali; a buffer; and a soap. In a heavy duty cleaner, the alkali might be furnished by caustic soda (lye, or sodium hydroxide); for milder cleaners such alkaline salts as trisodium phosphate, sodium meta- or sesqui-silicate may be used. The buffer is an agent tending to maintain constant alkalinity (pH) or strength over a range of concentrations. The soap is for increasing the wetting or "penetrating" power of the cleaner and for giving it free-rinsing qualities; rosin and/or synthetic wetting agents are often used. For certain heavy duty cleaning operations, a hand manipulated steam gun (that forces a hot, high pressure, alkaline spray combined with steam against the surface to be cleaned) may be used. The mechanical action of the steam-spray plus the chemical action of the hot alkaline solution has a powerful cleaning effect. The range of alkalinity (pH) varies with the type of cleaning operation: for light duty cleaners the range is 10.5-12.5; for heavy duty cleaners the pH range is 12-13.5. The concentrations of commercial alkaline cleaners vary as follows: *Type of Cleaning Equipment* — *Concentration of Alkaline Cleaner* Washing Machine — ½-1 oz. per gal. Steam Gun — ½-3 oz. per gal. Still Tank — 2-8 oz. per gal.	Alkaline cleaning is often considered the most economical method for removing greases and oils from iron and steel parts and for producing a chemically clean surface. Three main types of equipment are (1) still tanks, (2) washing machines, and (3) steam guns. The simplest way to clean is to soak the parts in a steel tank containing a solution of 2 to 8 oz. of commercial alkaline cleaner per gal. of water. Usually the cleaning solution is heated; submerged steam coils, steam jets, immersion heaters, etc., are used. Either the work or the solution must be agitated for maximum cleaning efficiency. Agitation of the solution is usually easier. Air jets furnish the most efficient agitation; steam coils, perforated or equipped with agitation shields, will do double duty heating and agitating the solution. The cleaning time varies from a few minutes to several hours. Washing machines are conveyorized series of washing, rinsing and drying operations. Parts are placed on conveyors or in trays and automatically carried through the various stages of the washing machines. Some types are manually loaded and unloaded, the remainder of the operation being automatic; others may automatically receive work from a conveyor system. Cleaning is usually accomplished by passing the parts through numerous high-pressure alkaline sprays. The work is then sprayed with clean water; heated air may be blown over the cleaned parts to dry them. The mechanical action of the sprays makes it possible to use low concentrations of cleaners: ½ to 1 oz. per gal.; and the cleaning time is from a few seconds to a few minutes. The steam gun is a convenient tool for cleaning large parts and equipment that cannot be immersed in cleaning tanks. It is easily handled by one person and, besides the gun, solution and steam hoses, a source of steam (at 30 p.s.i. or more) and a container for the cleaning solution are all that are needed. A 4-6 h.p., 30-80 p.s.i. boiler or a 60 p.s.i. or more steam line will furnish adequate steam.
Electro-alkaline Cleaning	Same as above—especially used as the final cleaning operation prior to electro-plating or vitreous enameling.	Commercial cleaners or a mixture similar to that listed below may be used: Sodium cyanide — 4 oz. Sodium hydroxide — 2 oz. Sodium bicarbonate — 1 oz. Water — 10 gal. A buffer and a wetting agent may be added to the above as these agents are usually included in the commercial product. The evolution of gas at the surface of the workpiece being cleaned loosens dirt and other foreign material quickly, making for a rapid and complete cleaning job.	A steel tank with a controllable source of d.c. current (6-8 v. and capable of delivering sufficient amperage so that a current density of 20-40 amps. per sq. ft.[1] is available), and equipped with steel electrodes, is necessary. Tank heating, agitation and ventilation requirements are the same as for still alkaline cleaner tanks. The cleaning time varies from about 3 sec. to 3 min. The efficiency of this process may be increased if the popularity of the work is reversed one or more times during cleaning. The increased efficiency and decreased processing time, as compared to the still alkaline cleaner tank, may balance the added expense and upkeep of the electrical system.

(Continued on page 113)

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Some Common Cleaning Cycles

Since the cleaning of steel parts is so largely dependent upon the use of cleaning cycles (or series of operations) rather than upon any single operation, some common cleaning cycles that include the cleaning operations listed on the preceding page and in previous "Engineering File Facts" pages are outlined below:

Type of Work to be Cleaned	Sequence of Operations in Cleaning Cycle	Remarks
Small parts requiring cleaning after oil quenching and oil tempering; also small sheet steel parts requiring the removal of rust-proofing, light dirt and rust.	1. Wash in solvent	See "Solvent Cleaners," in the Mar. 1944 M&A, p. 621.
	2. Drain	
	3. Wash in hot alkaline cleaner	
	4. Rinse in cold running water or spray	
	5. Dip in dilute hydrochloric acid	10% HCl (by vol.) in water
	6. Rinse in still water	Rinse will increase in acidity due to drag-in. After some use, it may be added to acid tank.
	7. Rinse in hot water	
	8. Dry or dip in hot rust-proof solution	Dry in hard wood sawdust or in warm air blast
Cleaning sheet steel prior to seam or spot welding (removing drawing compound, and rust-proofing).	1. Wash in hot alkaline cleaner	
	2. Rinse in running water	
	3. Dip in dilute hydrochloric acid	3% HCl (by vol.) in water
	4. Rinse in running water	May be the same rinse as used for step 2
	5. Dip in alkaline cleaner	May be the same tank as used for step 1
	6. Rinse in hot water and dry	Dry in warm air blast
Electro-cleaning stainless steel parts to remove dirt, scale, grease, etc.	1. Wash in hot electro-cleaner[2]	
	2. Rinse in running water	
	3. Dip in dilute nitric acid	2-3% HNO_3 (by vol.) in water
	4. Rinse in running water	May be the same rinse as used for step 2
	5. Rinse in hot water and dry	Dry in warm air blast
Cleaning steel stampings.	1. Wash in hot alkaline cleaner	
	2. Rinse in running water	
	3. Dip in dilute hydrochloric acid	3% HCl (by vol.) in water
	4. Rinse in running water	May be same rinse as used in step 2
	5. Dip in sodium cyanide bath	2 oz. of NaCN per gal. of water
	6. Rinse in running water	May be same rinse as used in step 2
	7. Rinse in hot water and dry	Dry in warm air blast
Steel parts cleaned in a typical automatic washing machine (the operations are those done in the machine).	1. Pre-cleaning spray	1. The pre-cleaning spray is either a hot alkaline cleaner or a mixture of an emulsifiable compound[3] and kerosene spray.
	2. Rinse in cold water spray	
	3. Wash in hot alkaline cleaner spray	
	4. Rinse in hot water spray	
	5. Dry or dip in hot rust-proof solution	

[1] *A current density of 20 to 40 amps. per sq. ft. is used for cleaning cathodically; if the work is made anodic, current densities of 50 to 100 amps. per sq. ft. are used.*

[2] *If the work is very dirty or greasy, a two-stage cleaning operation (a pre-cleaner and a final cleaner tank) is recommended.*

[3] *This emulsifiable compound is a heavy, neutral, oil-soluble liquid that is non-inflammable and is sprayed on the work to be pre-cleaned after being mixed with kerosene (or some similar solvent) in the ratio of 1 part of liquid cleaner to 10 parts of kerosene. This spray cleaning will produce a physically clean surface.*

Compiled by Robert S. Burpo, Jr.

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METALLURGICAL ENGINEERING shop notes

Safety Inserts for Tapping Heads

by Bill Stull,
Glenn L. Martin Co.

A new safety insert for tapping heads has almost completely eliminated tap breakage on jobs where as many as six taps per shift were broken. Particularly severe was breakage in tapping of hard, heat-treated gun charger plates and bomb bay window racks.

Broken taps would so jam into holes being threaded that 50% of the jammed work was scrapped. Since tapping was the final operation on the plates and racks, man hours and materials lost were considerable.

Three of us began experimenting. Our first plan was to cut a groove near the top of each tap so that if the tap jammed, it would break at this weak point above the level of the work, hence accessible for removal. This helped some but did not solve the problem.

We finally evolved a safety insert, in the form of a grooved piece of Zamak, a soft zinc base alloy, which replaces the steel jaws formerly used to hold the tap in place, and is the same size and shape as those jaws. However, whereas the jaws are in two pieces and adjustable to take various sized taps, the Zamak insert is cast in one piece; thus, each insert can be used only with the size tap for which it is designed.

Now when a tap jams, the soft metal of the insert slot wears away, permitting the tap to remain stationary while the tapping head continues to rotate. The soft metal gives away before sufficient force is generated to break the tap, but the metal is hard enough to hold the tap in place during normal operations. By rotating the insert to a new position each time a tap jams, the same insert may be used about 15 times, after which it can be melted and recast.

Since using these safety inserts not a tap has been broken, nor work scrapped. The three of us who developed the device are Ed Lapoz, second shift general foreman of machine shop at Glenn L. Martin; Fred Lang, second shift foreman of drill presses, and the author of this sketch, second shift departmental supervisor of detail manufacturing—all appearing in the accompanying photo.

Movable Wire Mill Snarl Switch

by L. Larson,
Columbia Steel Co.

A snarl switch in a wire mill is a device containing a metal eye of—say 4 in. diam.—through which the rod or wire passes before it enters the die of a wire drawing machine. The switch both prevents a snarl from entering the drawing die, and stops the operation of the wire drawing machine.

The conventional snarl switch is rigid, and with it the wire block would not stop in time to prevent the rod from breaking, necessitating re-threading the rod into the die.

At the Pittsburgh, Calif. plant, we designed a sleeve type of snarl switch. The frame is an open rectangle, made of steel rod, about 2½ ft. by 1 ft., on one end of which is placed an approximately round eye, 4 in. in diam.

This switch is moved back a foot from its former position, so that as a snarl enters the eye the switch tilts forward, allowing the snarl of the rod to "drift" through it until the wire drawing machine comes to a dead stop. The new type prevents breakage and hence makes threading unnecessary. It also allows the wire drawer sufficient room to untangle the snarl and straighten the rod prior to resuming operations.

The tilting of the switch forward may be likened to the principle of a prize fighter "riding with the blow" delivered by his opponent, thus escaping serious injury.

In the arc welding of light sheet metal there is always the danger of burning holes. One preventative or remedy is to keep handy an oxyacetylene cast iron rod. At the first sign of a burn through, the operator backs the hole up with the end of that rod. The hole can then be welded over without choking the arc or cutting the machine down. The cast iron rod can be removed with ease, leaving a neat weld and a smooth under surface.

—"The New Welding Arcs," General Electric Co.

Battery Truck in Wire Mill

by William I. Ong

In the new South Works wire mill of the American Steel & Wire Co., Worcester, Mass., the conventional "wire buggy" has been displaced by 11 battery industrial trucks, which are a marvel of efficiency and speed. This is the first time such

carriers have been used in a mill of the A. S. & W. Co.—and perhaps any wire company.

The trucks are exceptionally adaptable for short hauls, and are readily manipulated in small spaces. They are easily reversed, turned about and are suitable for quick maneuvering. They have eliminated much of the double handling that proved so unsatisfactory in a mill that is built around short hauls.

Moreover, the rubber-tired, four-wheeled trucks inflict less damage on the concrete flooring of the mill than many types of steel-wheeled vehicles. They can be easily converted to either a ram type or fork type truck, the former for coils, the second for skids or pallets. Capacity is 6000 lb.

—American Steel & Wire Co.

Perhaps this is more of a "human interest" item than a practical "shop note" —yet it shows what can be done in an emergency. An American pilot had to land on an island dominated by the Japanese, his airplane radiator riddled with bullets. He cut the top and bottom from a can of baked beans and, with a blow torch and soldering iron, soldered the discs of tin over the damaged end of his radiator. Within an hour he was on his way back to his own base.

—News Release from Steve Hannagan

Preventing Armor Plate Distortion

by Carl G. Strandlund,
Chicago Vitreous Enamel Product Co.

Instead of allowing armor plate to distort in process and then straighten, we prevent it from distorting in the first place through use of our new "waffle iron" dies in a large press. By the conventional method, armor plate is heated to 1500 to 1600 F., then quenched in cold water.

Unless the plates are held rigidly, this sudden cooling causes the steel to become distorted or warped. Then it must be put through big presses for straightening, a lengthy process.

We devised the "waffle iron" dies for flat pieces, containing 7,200 holes through which water is ejected. When the press locks a slab of red hot armor plate against the die, streams of water from the holes quickly quench the plates.

The press meanwhile exerts 2500 tons of pressure against the slab, and it emerges as flat as a billiard table. It is possible to design dies to shape plates into other than flat surfaces also.

Previously, it took 15 man-hours to heat treat and straighten a slab. By the new method only 6 or 7 min. are needed. One of our presses does the work of 25 cold-straightening presses.

At our Cicero plant alone, 1,000,000 man-hours and 500,000 machine-hours were saved in 1943, with a cost saving of 9¢ per lb.

Often high alloy steel snagging chisels are worn too short apparently to be used for chipping any more castings. However, we heated and forged these stubby chisels until they were just as long as when new, only smaller in diameter—just the size to fit a smaller chipping hammer.

—War Production Drive Bulletin, Westinghouse Elec. & Manufacturing Co.

Finding Cracks With Ultraviolet Rays

by J. A. Sams,
General Electric Co.

Often parts made from non-magnetic materials, such as aluminum, copper and their alloys, have cracks that are invisible under ordinary inspection. Yet when dipped in a special preparation, consisting of a penetrant with a fluorescent powder dissolved in it, and subjected to a fluorescent test with ultraviolet radiation, defects, such as cracks, appear instantly.

The test can be applied to the inspection of parts for planes, searchlights and other war products.

In the accompanying photograph the author examines an aluminum piston, seeing a crack that did not appear at first.

Rubber Rollers on Saw Table

by F. A. Denz,
United Air Lines

When aluminum alloys are sawed across a bare table, as has been the practice for many years, much wastage has resulted. In any kind of die and hammer work the material must be free from all blemishes.

In structural parts, where there are radii, a small scratch often will cause a failure in required strength. This applies extensively in our skin-stressed airplanes of today.

Previously United Air Lines employees were sanding and polishing all pieces sawed, most of which were to be stamped into some form for airplanes. We began to consider quicker methods. The first idea was to sand the table with crocus cloth and remove all sharp corners and edges.

Scratches, however, continued to appear when workers would saw soft alloys and steel. The steel would scratch the saw bed, and when aluminum was moved over its surface, the material would gall and again cause indentations.

The final solution was the installing of a set of small rollers covered with rubber, a material that has no galling characteristics. With this arrangement, too, filings and shavings will fall through, out of the way and on down to the saw table. Again, it is much easier to push the work into the saw blade.

Credit for this device goes to L. H. Hurt, of United's bomber modification center at Cheyenne, Wyo. For this Mr. Hurt received $75 and a War Production Board merit award.

Wooden tanks, the two sides fastened together by Monel tie-rods, hold hot 7 per cent sulphuric acid pickling solutions, at 188 deg. F., and have been used through two wars at the Pittsburgh plant of the Hanlon-Gregory Galvernizing Co. The original tie-rods were of steel, covered with lead. But corrosive action ate through this sheathing, particularly where the rods were threaded. They were replaced every three months. Monel was tried and an annual saving of $738 per tank was realized, despite higher original cost. They lasted 12 times as long. Later they can be reworked and made into pins and other fittings.

—"Inco," International Nickel Co., Inc.

Metallurgical Engineering Digest

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Chrome Oxide in Open Hearth Slags

Condensed from "Blast Furnace and Steel Plant"

With larger quantities of chromium scrap available, it has been found that greater percentages of such scrap can be used than heretofore thought possible. The principal problems are to get this chromium-contaminated scrap melted as rapidly as chromium-free scrap, and to obtain a workable slag so that the metal can be properly refined.

After observing a number of characteristics of chromium charges, a number of heats were made trying various practices. These showed that if more than a definite amount of chromium is charged, furnace delays will occur. Lime must be put into solution at the very earliest. Slags of less than 1.0 lime-silica ratio ("V") will always cause trouble. Up to 8.0% Cr_2O_3 in the slag will cause no trouble if the basicity at melt-down is 1.0 "V" minimum.

Chromite spinels cause the trouble. If a slag has a minimum basicity of 1.2 "V" at melt-down, it will be possible to have most of the chromium in oxide form rather than in spinel form. In such cases, the Cr_2O_3 is in solution in the oxide phase of the slag. Very seldom will a residual chromium of more than 0.15% be found if a spinel slag has formed.

No silicon additions of any kind should be made to a spinel slag or to a slag with a high percentage of Cr_2O_3. If a slag has a tendency to thicken, fluorspar and fine ore, or roll scale, should be added. A sintered lime plus ore is also very good.

No attempt should be made to make high-carbon heats with spinel slags. Load the bath with ore and get the carbon below 0.50% as fast as possible. Scrap should be charged as rapidly as possible and melted more than the usual practice before the pig-iron is added.

The mineralogical rather than the chemical composition of the slag is the governing factor. There is a definite relation between the Cr_2O_3 content of the slag and "V". The quality of the steel produced depends greatly on the method of working the heat, the final slag developed, and the method and type of deoxidation.

By substituting graphite for pig-iron, larger percentages of alloy-contaminated scrap may be used. With such charges it is advisable to use some spiegel or fine manganese, and some silicon-pig to make up for a part of the manganese and silicon contained in the pig-iron. About 50 to 60% of the manganese and 25 to 35% of the silicon should be sufficient.

The graphite-plus-scrap charge may possibly be of great benefit in melting stainless scrap. The efficiency of the graphite may be somewhat lower than with regular chromium scrap. Silicon is very detrimental to rapid melting and proper slag formation, and decreasing it may be of some advantage.

The percentage of chromium and manganese recovered with a graphite-plus-scrap charge will be somewhat different from that with the regular cold or hot-iron-plus-scrap charge.

The graphite-charge heats apparently work differently from the conventional pig-iron-plus-scrap charges. All the slags from the graphite-charge heats were fluid in the furnace, whereas the slags of the hot-metal charge were considerably more viscous. No fluorspar was necessary to work the graphite slags, and ore reacted rapidly. These conditions were not true of the hot-metal-charge slags.

Chromite spinels were more numerous in the hot-metal-charge heats, although the balance of the mineralogical composition showed only minor differences.

—C. R. Funk, *Blast Furnace & Steel Plant*, Vol. 32, Apr. 1944, pp. 448-454.

Fire Clay Grog Bodies

Condensed from "Industrial Heating"

Improvement in refractory grog bodies has been reported through the use of clay slips, deflocculents, and hot water in their preparation. Walter A. Hedden, of New York State College of Ceramics, discussed these results in a paper presented before the Refractories Division of the American Ceramic Society at Pittsburgh.

Dry properties of the refractory, such as density, shrinkage and modulus of rupture, showed improvement when the bond clay was added as a slip rather than as dry clay.

695 Plastic Magnesia Refractory

For a hundred hot repairs

695 is a convenient, ready-to-use plastic basic refractory. It is as handy to the furnace operator as putty in a paint shop.

Open hearth and electric steel men find 695 ideal for quick, hot repairs of furnace hearths and linings—for open hearth front walls and backwalls, skewbacks, monkey walls, bridge walls and air uptakes, for lining open hearth runners and electric furnace spouts, for patching holes and cracks in big ingot molds, and for repairing soaking pits. Numerous other successful, emergency applications are noted regularly.

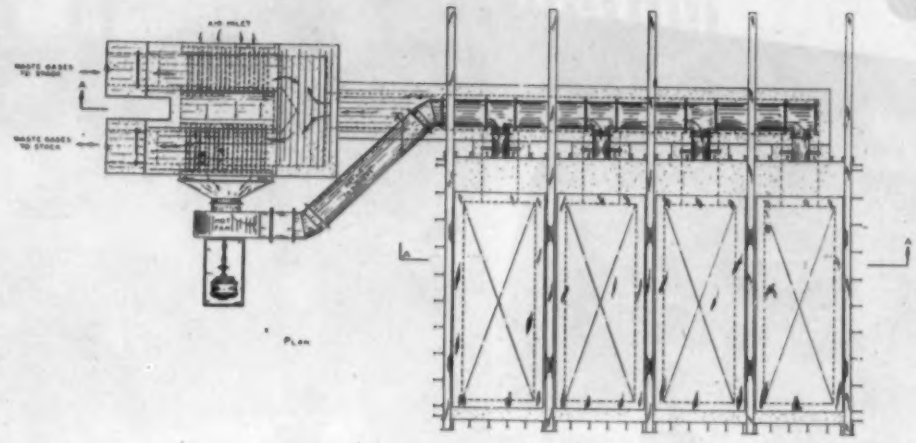
This plastic is best known, perhaps, as a tap hole material, the application for which it was originally designed. That is still its largest use. Customers report that 695 tap holes frequently give twice to three times the number of heats obtained with previously used mixtures.

695 has a melting point well above 3600°F—verified by pyrometric cone tests and substantiated by its satisfactory performance over long periods in the hottest parts of both electric and open hearth furnaces.

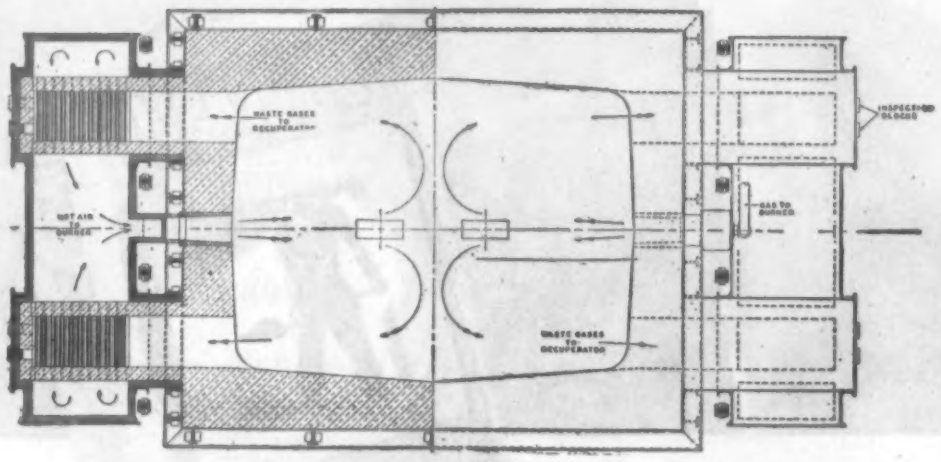
If you haven't been using 695, now is the time to take advantage of its time and trouble saving features. It comes in convenient 100-pound bags ready to mix with water. Include some in your next carload order of refractories.

BASIC REFRACTORIES, INCORPORATED *Cleveland 15, Ohio*

"FITCH" RECUPERATORS for SOAKING PITS



Four holes equipped with a single recuperator.



A single hole equipped with four recuperators.

To date there are over 170 pits of various designs equipped with "Fitch" Recuperators. Many of these pits have replaced the regenerative type previously used, resulting in a greatly increased tonnage of steel heated.

WE DO NOT BUILD FURNACES

Write for Bulletin No. 12

"FITCH" RECUPERATORS for the STEEL INDUSTRY

FITCH RECUPERATOR CO.

PLAINFIELD NATIONAL BANK BLDG. PLAINFIELD, NEW JERSEY

Addition of 40% of the clay in a 50-50 body as slip increased the dry strength of the body.

While inorganic deflocculents caused a decrease in the refractoriness of the body, the use of organic materials did not cause this decrease. The greatest dry strength was obtained in bodies formed with 0.5% soda ash and hot water.

Additions of 0.2% soda ash increased dry strength with some loss of refractoriness, and additions of 0.05% had no effect. Ammonium tartrate, to the extent of about 0.3%, increased dry strength of the bodies.

Hot water made the electrolytes more effective, it was stated, and dry strength showed an increase when it was used instead of cold water.

The results of tests upon specimens of 20 cycles of heating to 850 C. and plunging into water indicated a superiority for the specimens prepared by these methods as compared to those made by the usual methods, with dry clay and cold water. Specimens made by the usual methods showed greater loss of strength after this alternate heating and quenching test.

—*Industrial Heating*, Vol. 11, Apr. 1944, pp. 618, 620.

High Frequency Aluminum Furnaces

Condensed from "Light Metals"

East of transmission and conversion of electrical energy into heat in the electric furnace makes this a convenient tool capable of meeting the most diverse needs of technology. The exacting demands that the quality of modern structural materials, particularly the light metals, must supply are among the primary reasons for a wider resort to electrothermics.

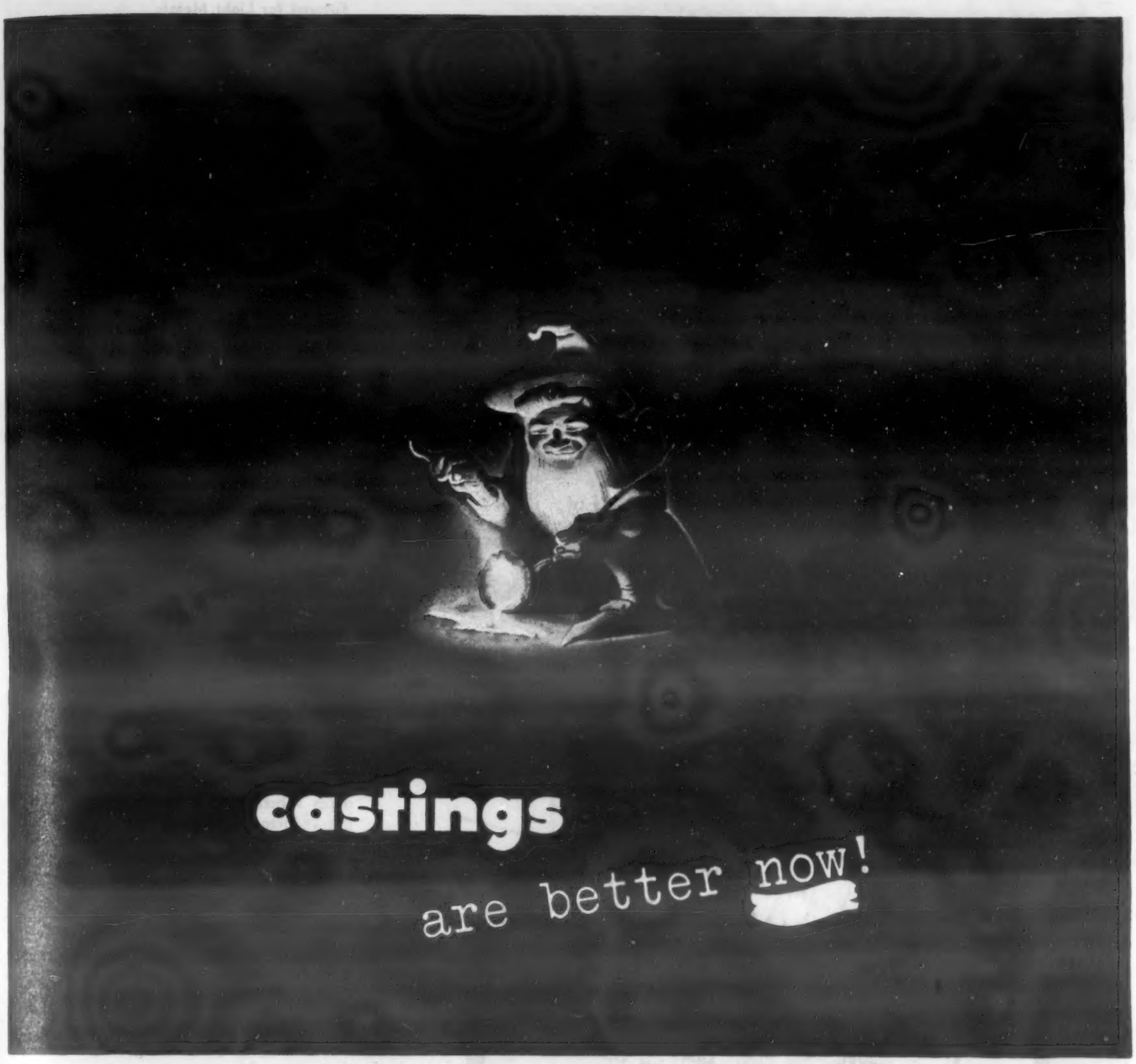
Electric furnaces possess several technical advantages over other methods of heating, such as the possibility of obtaining very high temperatures, localization of energy at any one point, flexibility of heat regulation and simplicity of control, and cleanliness in use.

The shape of the furnace can be fitted to production requirements, and the working chamber of the resistance or induction furnaces may be insulated from the surrounding atmosphere, a feature of great importance in melting aluminum. Uniform heating and conditioned atmosphere may often be decisive advantages.

Restricted application of electric furnaces is dictated merely by relatively high cost and lesser availability of cheap electric power. In spite of these handicaps, industrial electrothermics show a vigorous growth in all countries.

Of the three types of electric furnaces—arc, resistance, and induction—the last presents the largest sphere of interest to the light-metals technologist. It is the most perfect method, as the heat is created within the metal mass itself.

Furnaces are of two types, those with, and those without iron cores. The latter type has the larger field of application, as it does not require maintenance in the furnace of a certain quantity of liquid metal for closing the secondary circuit. This permits quick changes from one metal to another.



With new formulas, new procedures, new tests and controls, the foundryman has come a long way. Time was when an iron or steel casting was just a molded object of indefinite character. Now, more often than not, it is an embodiment of specified properties for exact engineering uses. In conjunction with the great improvement of welding and with other factors lately developed, this brings us to a new Machine Age.

Alloys have a growing importance. On metallurgical materials and their effects, knowledge is highly specialized. Seemingly slight differences lead to widely different results. The best advice obtainable and the most careful attention to details, are conditions of success. For those who keep up with the advance, there are great things ahead.

Inquiries concerning any use of Boron, Tungsten, or Molybdenum will be welcomed by the Molybdenum Corporation.

AMERICAN Production, American Distribution, American Control—Completely Integrated.
Offices: Pittsburgh, New York, Chicago, Detroit, Los Angeles, San Francisco, Seattle.
Sales Representatives: Edgar L. Fink, Detroit; H. C. Donaldson & Co., Los Angeles, San Francisco, Seattle.
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GRANT BUILDING PITTSBURGH, PA.

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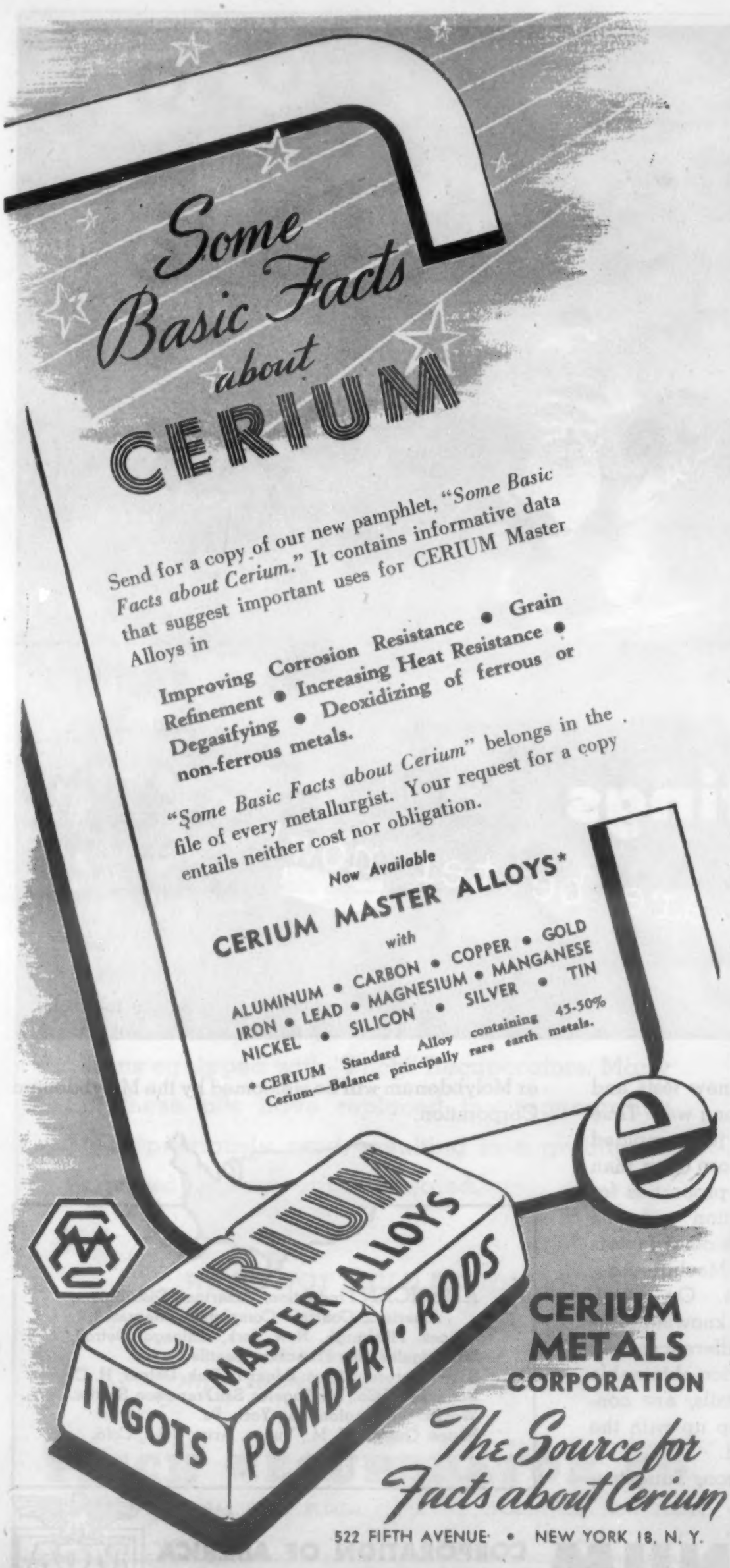
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Send for a copy of our new pamphlet, "Some Basic Facts about Cerium." It contains informative data that suggest important uses for CERIUM Master Alloys in
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Favored for Light Metals

Heating by eddy currents promoted by high frequency is widely utilized in ferrous metallurgy, and is rapidly winning favor in the technology of light metals. The reason for the extensive use of the coreless furnace may be found in the progress of manufacture of the static condenser. High cost of the compensating condenser has been the chief obstacle to wide use of inductive heating.

Advantages of the coreless furnace are: great simplicity and compactness of design; possibility of yielding metals of required analysis, due to almost complete isolation of the melting space from the atmosphere; precision of working, and possibility of achieving a relatively simple hermetically-sealed construction.

An important technological characteristic of the induction furnace is the intensive agitation of the bath, preventing non-uniformity and accelerating chemical reactions. Only silica or alundum crucibles are available for large-capacity furnaces at present, although steel pots imbedded in a magnesite mass are successful for magnesium.

A crucible developed in Sweden from a basic material termed "magnesigon" gave quite promising results. It has a coefficient of linear expansion even lower than that of silica.

Theoretical considerations allow or even necessitate reduction of frequency in the coreless furnace as furnace diameter increases. The cost of the generating plant decreases as frequency is lowered, but the cost of condenser equipment rises.

Recently there appeared induction furnaces functioning on dual frequency, with the inductor fed by two unconnected systems. The higher frequency affects melting, while the lower is employed after the melting, and serves for agitating the metal.

There are at present two principal types of high frequency generators, those with electronic valves, and rotary machines. Apart from these, there was recently evolved in Russia the so-called "Herzetron" generator, which promises to solve the problem of obtaining great power at high frequencies. It combines the properties of thyratron and electronic valve.

—B. J. Brajnikoff, *Light Metals*, Vol. 7, Feb. 1944, pp. 55-61.

Sharpening Rough Rolls

Condensed from "Stahl und Eisen"

In steel mill practice the sharpening of ragged rolls was originally done by hand or by compressed air chisels. Skilled labor was necessary to ensure uniformity of sharpening and proper contour of the depressions. Later, special milling machines and lathes for roll sharpening were introduced, replacing manual work.

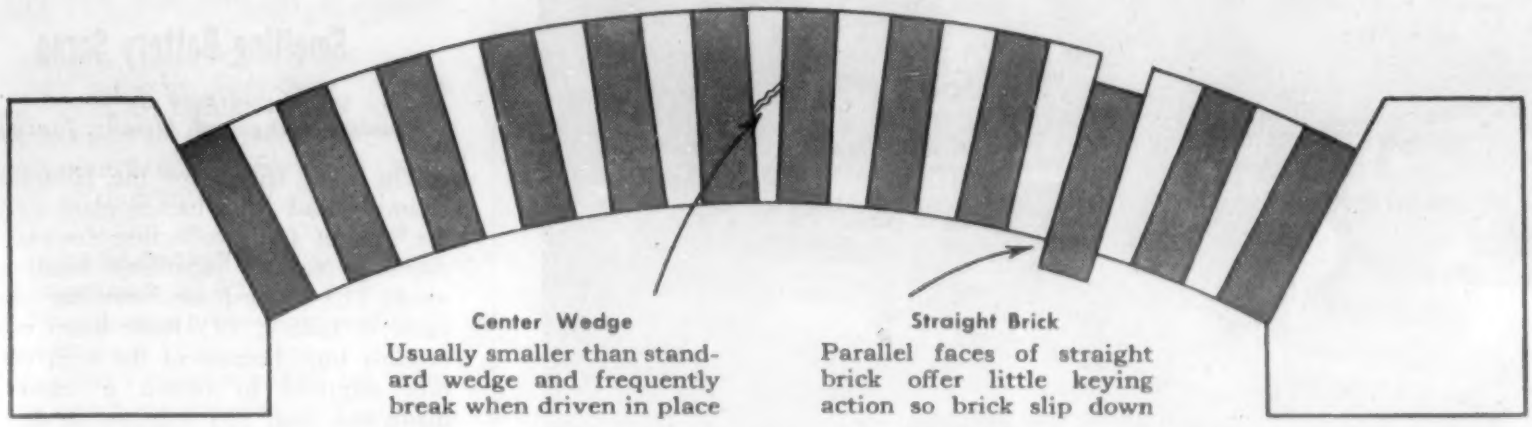
Now the tendency is to use roll sharpening lathes because of limitations inherent in the milling process, the requirements of specially shaped milling cutters, and the need for highly skilled machine operators.

Advantages of the lathes are: shorter working time needed, and the possibility of dressing knobbling rolls (which break up scale effectively and increase biting power) as well.

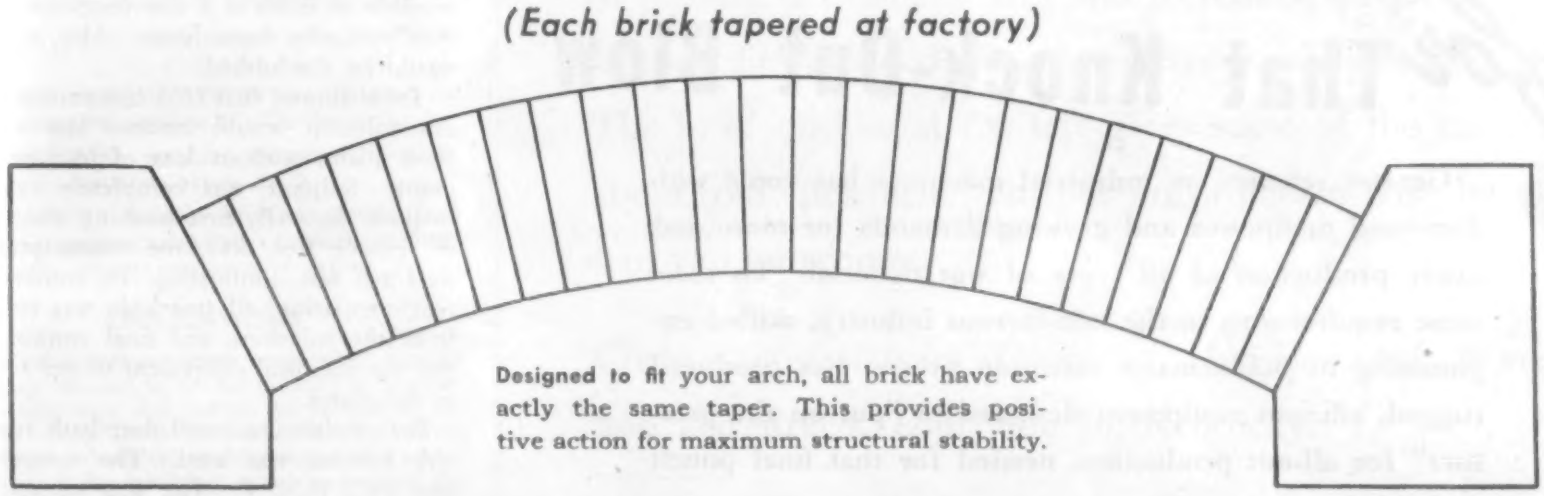
Again, with the lathe ordinary cutting

USE "TAILOR-MADE" ARCHES
For Maximum Structural Stability

ORDINARY METHOD OF ERECTING FURNACE ARCH
(Alternate straight and wedge brick)


Center Wedge
Usually smaller than standard wedge and frequently break when driven in place
Straight Brick
Parallel faces of straight brick offer little keying action so brick slip down

ARMSTRONG'S INSULATING FIRE BRICK IN A "TAILOR-MADE" ARCH
(Each brick tapered at factory)



Designed to fit your arch, all brick have exactly the same taper. This provides positive action for maximum structural stability.

ARCHES made of Armstrong's Insulating Fire Brick—all cut to the same size and angle—lay up faster and are stronger. When ordering, simply state the span, rise, thickness, and length of the arch. The brick will then be precision-machined at the factory to fit your arch, and you'll get them at standard wedge brick prices. In addition, the large ends of tapered brick are marked with a colored dot to save time in laying and to prevent costly errors in construction.

Tailor-made arches are available in all five types of Armstrong's Insulating Refractories for temperatures from 1600° to 2600° F. All five types have high crushing strength (hot and cold), low thermal conductivity, high resistance to spalling, and low heat storage. They are the result of Armstrong's 30 years' experience in the manufacture and application of efficient, dependable insulating fire brick.

For complete factual information and practical engineering help, write today to Armstrong Cork Company, Insulating Refractories Department, 5501 Concord Street, Lancaster, Pennsylvania.

5200-ton Tube and Rod Extrusion Press

for **That Knock-Out Blow**

Greater reliance on industrial machines has come with decreased manpower and growing demands for more and faster production of all types of war material. To meet these requirements in the non-ferrous industry, skilled engineering of Schloemann extrusion presses has produced rugged, efficient equipment designed to "put on the pressure" for all-out production, needed for that final punch at the Axis.

Produced daily on Schloemann Extrusion Presses of the type shown above, miles of high tensile sections of aluminum and magnesium alloys are now giving our Air Fleet the staying power demonstrated on all fronts. Likewise, for our Battle Fleet and Merchant Marine, condenser tubing of copper alloys is being produced in great quantities.

* Hydraulic Presses
* Air-Hydraulic Accumulators
* Accumulator Controls
* Engineering of Complete Hydraulic Systems
* Extrusion Presses

SCHLOEMANN
ENGINEERING CORPORATION

1104 Empire Building . . . . . Pittsburgh, Penna.

HYDRAULIC PRESSES • ROLLING MILL MACHINERY

tools can be used, provided the distance between the projections is not less than four or five times the thickness of the projecting ridges.

For knobbling rolls with clearances less than 1.5 times the peripheral width of the projection, a roll sharpening lathe becomes impossible and a mill cutter must be used. Care must be taken not to cut below the profile diameter to make the radius sufficiently large and to avoid the formation of sharp edges in order to prevent the adherence of scale.

—O. Rademacher. *Stahl u. Eisen*, Vol. 63, June 3, 1943, pp. 446-447; as translated in *Engineers' Digest* (British), Vol. 5, Jan. 1944, p. 13.

Smelting Battery Scrap

Condensed from "Engineering and Mining Journal"

The chief reason for the failure of reclaiming lead from battery-plate scrap was the lack of fume collecting devices. Conclusions reached regarding small plants were: (1) Fume losses were the principal cause of failure; (2) fume losses were inevitably high because of the high temperature required to obtain a free-running matte and slag; (3) sulphate in the scrap, being the primary cause of mate, was the fundamental cause of both fume and slag-matte losses, and (4) an inexpensive method of removing sulphur would make it possible to smelt at a low temperature and thus minimize fume losses. Also, slag loss would be diminished.

Tests showed that cold concentrated soda ash solution would remove the sulphur from plates without loss of lead or antimony. Sulphur was completely removed in three days. By first washing with water to remove free acid, the consumption of soda ash was diminished. By counter current circulation, all free soda was removed from the solutions, and final consumption was the chemical equivalent of the sulphur in the plates.

For smelting, a small deep-bath reverbatory furnace was used. The temperature was 1472-1652 F. The flux consisted of soda, borax and fluorspar on the surface of the charge. Reduction was rapid. Slag was skimmed off twice and replaced with new flux. Recovery of lead and antimony was 98.5%.

The product from complete smelting of battery plates is sometimes not readily marketed. This fact led to a series of softening experiments that gave some interesting results.

The object was to develop the following characteristics: (1) Operation to be carried at such temperature that steel could be used as container; (2) flux to absorb antimony, but little or no lead; and (3) spent flux to be fused with carbon to reduce antimony to metal and regenerate flux for re-use.

The principal facts established by the softening tests were: (1) Optimum operating temperature was 1256 to 1328 F. Below 1256 F. softening was slow, and above 1328 F. deterioration of the pot and blowing tubes was excessive; (2) flux could be re-used, but, becoming sticky after successive reductions, required high temperatures for fluidity.

A FEW FACTS ABOUT CORHART PRODUCTS

Corhart Electrocast Refractories are high-duty products manufactured by melting selected and controlled refractory batches in electric furnaces, and casting the molten material into molds. After careful annealing, the finished shapes are ready for shipment. Dense, high-melting refractories, they are especially designed for resistance to corrosive action.

PRODUCTS

CORHART STANDARD ELECTROCAST is a high-aluminous refractory.

CORHART ZED ELECTROCAST is Zirconia-bearing.

CORHART ELECTROPLAST is a high-temperature plastic refractory made from Standard Electrocast which has been ground and crushed. Especially designed for ramming. Furnished dry.

CORHART MORTAR is a high-quality cement for laying up Electrocast, clay brick, or any aluminous refractory.

CHARACTERISTICS OF STANDARD ELECTROCAST

POROSITY: Less than 0.5%—therefore virtually no absorption.

FUSION POINT: Cone 38 without any appreciable softening below that point.

HARDNESS: 8, Mineralogist's scale.

SPECIFIC GRAVITY: Blocks weigh approximately 183 lbs. per cu. ft.

COEFFICIENT OF EXPANSION: 0.000006 between room temperature and 900° C.

SPECIFIC HEAT: 0.25 cal. per gm. per °C. at 980° C.

THERMAL CONDUCTIVITY: 25 BTU per sq. ft. per hour for gradient of 1°F. per inch.

COMPOSITION: Standard Electrocast is of an aluminous crystalline nature.

CORROSION: Because of low porosity and inherent chemical make-up, Corhart products are highly resistant to corrosive action.

APPLICATIONS

Most heat processes present spots where a better refractory material is needed in order to provide a balanced unit and reduce the expense of repeated repairs. It is for such places of severe service that we invite inquiries regarding Corhart Products as the fortifying agents to provide the refractory "balance" desired.

The following is a partial list of applications for which Corhart Products are suggested:

ELECTROLYTIC CELLS — for production of Magnesium and other light metals.

SILICATE OF SODA FURNACES — sidewalls, bottoms, and breastwalls.

HEARTHS AND SMELTERS — for non-ferrous metals.

ALKALI AND BORAX MELTING FURNACES — fast-eroding portions.

GLASS FURNACES — the entire installation of flux walls and bottoms, breastwalls, ports, tuck-stones, forehearths, recuperators, etc.

RECUPERATORS—tile, headers, separators, etc.

ENAMEL FRIT FURNACES — flux walls and bottom.

BRASS FURNACES — metal contact lining.

ELECTRIC FURNACES — linings for rocking type, and rammed linings of Electroplast for this and other types.

BOILERS — clinker line.

STOCK SHAPES AND SPECIALS

Standard and Zed Electrocast are made in stock shapes and in many special shapes. The weight of individual pieces may run to 3500 pounds.

IF YOU NEED A BETTER REFRACTORY—

● Corhart Electrocast Refractories are high-duty products which have proved considerably more effective than conventional refractories in certain severe services. If your processes contain spots where a better refractory is needed to provide a balanced unit and to reduce frequent repairs, Corhart Electrocast Refractories may possibly be the answer. The brief outline at the left gives some of the basic facts about our products. Further information will be gladly sent you on request.

Corhart Refractories Company, *Incorporated,* Sixteenth and Lee Streets, Louisville 10, Kentucky.

"Corhart" is a trade-mark, registered U. S. Patent Office.

QUALITY ECONOMY ENDURANCE

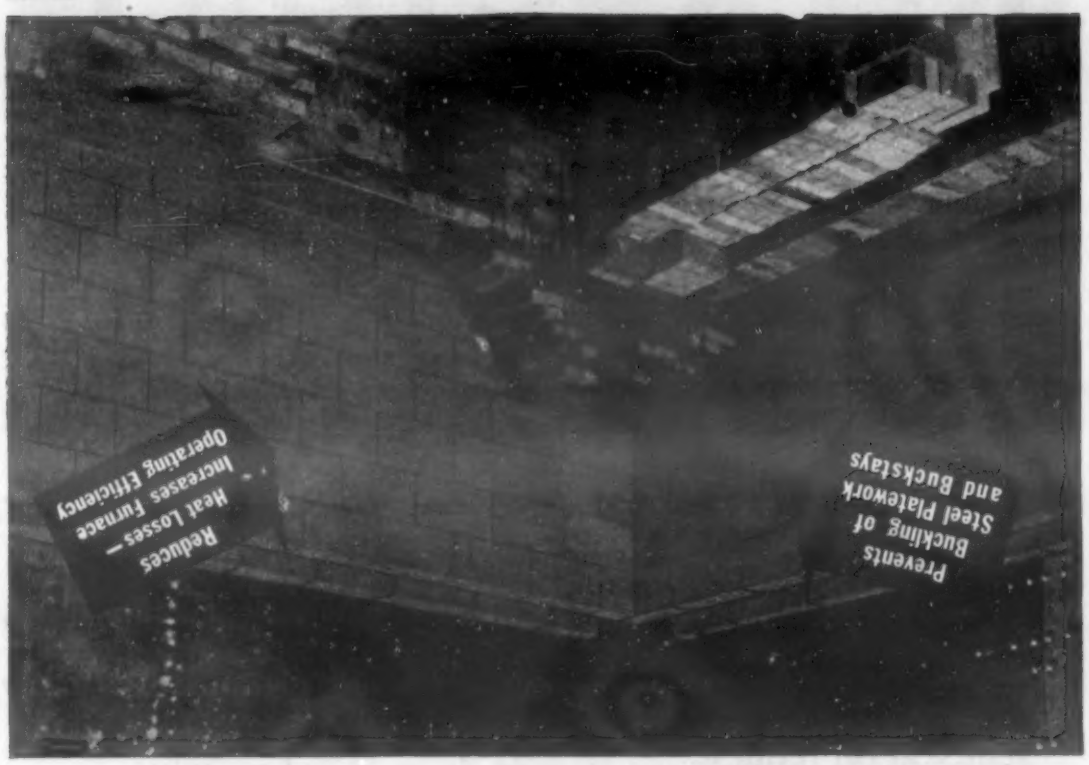
CORHART ELECTROCAST REFRACTORIES

This

LIGHTWEIGHT INSULATING BRICK

does "Double Duty"

in Furnace Walls



CONVENIENT 13½ x 9" SIZE—EASY TO HANDLE

REDUCES WALL JOINTS 65%

Other forms of THERM-O-FLAKE INSULATION

Coating — Seals and Insulates all types of furnace walls. Highly plastic, works and spreads easily.

Blocks — Highly efficient insulation where larger size units may be required.

Concrete — Monolithic castable insulation with high insulating value.

Granules — Loose-fill, efficient insulation, weighs only 6 pounds per cubic foot.

Protects furnace steelwork and plating from excessive heat with a strong resilient cushion which absorbs expansion stresses.

KEEPS HEAT INSIDE FURNACE WALLS

Excellent insulation,— a 4½ inch thickness being equivalent in heat flow, resistance to more than 29 inches of fire brick.

Find out how quickly THERM-O-FLAKE Brick will pay back their cost in reduced furnace heat losses. For specific data, indicate type of furnace and approx. operating temperatures in writing to:

Illinois Clay Products Company
JOLIET, ILLINOIS

Therm-O-flake BRICK

FOR HOT FACE TEMPERATURES UP TO 2000° F.

(3) Antimonial lead obtained from reducing the flux contained 40 to 50% Sb. A 98% Sb product was made by agitating normal saturated flux on 40% antimonial lead, and then removing and reducing it; (4) mixing nitre with the charge increased rate of softening.

(5) As antimony oxidizes and enters the flux, fluidity of latter increases; and (6) if tin is present in the lead, it oxidizes before the antimony and tends to make flux sticky, but if blowing is continued until antimony oxidizes, the flux becomes fluid.

On the basis of the results obtained in this work, a much larger unit was set up at a commercial refinery. It was found that corrosion of the steel was more serious in the pilot plant.

A solution was found in remodeling a laboratory Kjellin furnace. This type of equipment could be built to operate in units of 25 to 50 tons daily capacity.

In order that the whole process might be continuous, a process for recovering antimony and regenerating the flux was developed.

—Carle R. Hayward. *Engineering & Mining J.*, Vol. 145, Mar. 1944, pp. 80-83.

Blowing Rates for Blast Furnaces

Condensed from "Iron and Steel Engineer"

The need for maximum pig iron production during the present war emergency has called attention to the need for producing the maximum possible tonnage from existing furnace stacks—or that existing furnaces should be blown with the maximum possible wind volume that can be used without producing conditions that will defeat the purpose.

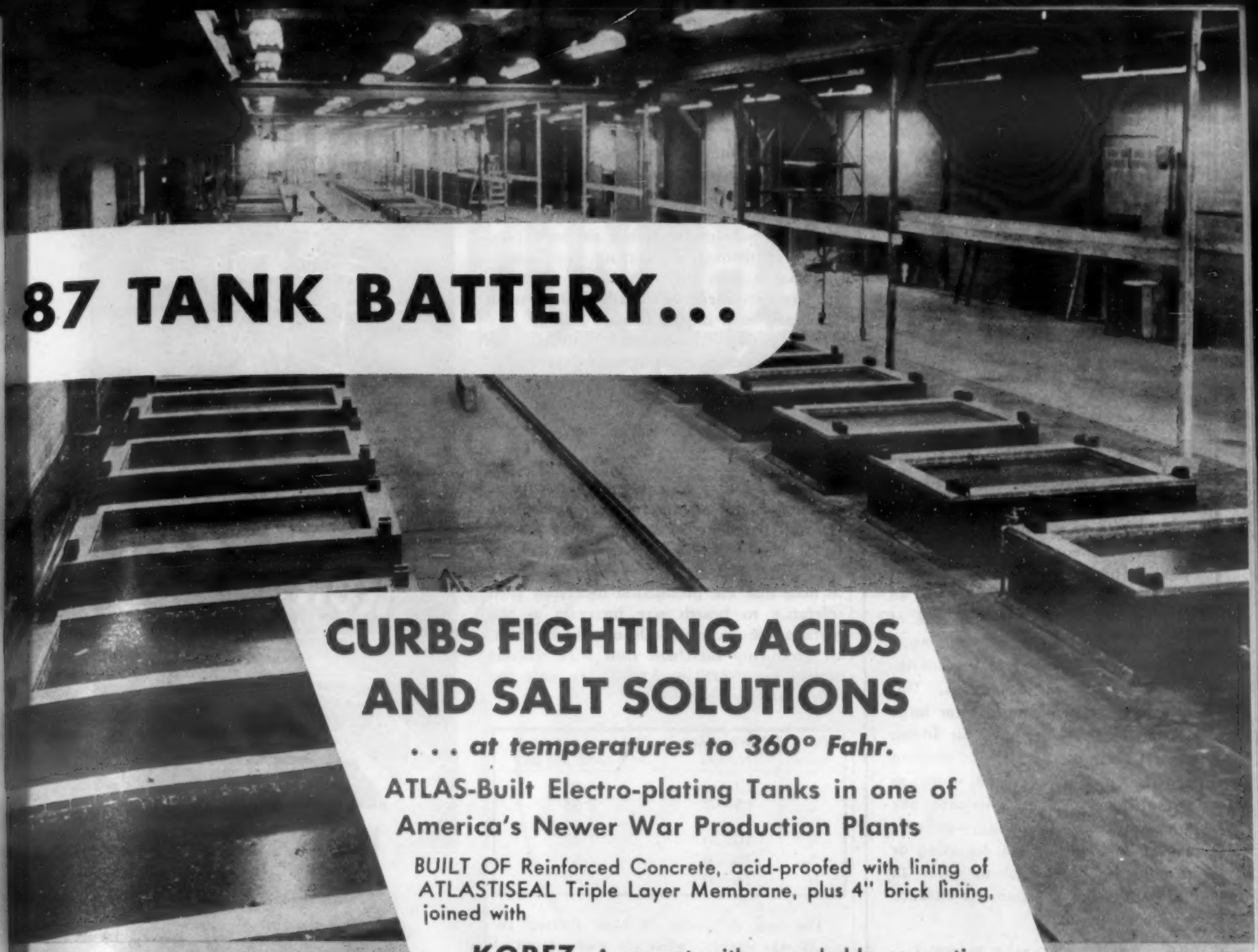
Assuming the proper qualities of the materials charged, and its proper placement in the furnace top, the tonnage of iron that will be produced is measured directly by the wind volume that is used. In other words, the production capacity of any furnace, all other things being equal, is measured by its ability to burn coke.

Various yardsticks have been suggested to measure the probable coke burning capacity of a blast furnace. Sweetser suggests a figure of 60 lb. of coke per cu. ft. of working furnace volume per 24 hr. as a unit of measure. Some years ago the Bureau of Mines studied some 14 Southern furnaces and suggested a rate of 3.28 lb. per min. per sq. ft. of hearth area.

Another commonly used yardstick to measure blowing rate is by the volume blown per unit of hearth area. With the small furnaces of the past a volume that equalled 180 cfm. per sq. ft. of hearth area was considered the reasonable maximum. With the large furnace of today, this blowing rate per unit of hearth area cannot be maintained, and with the continued increase in hearth diameters it has been necessary to decrease this rate to about 130 cfm. per sq. ft. of hearth area.

Other Items Affect

The correct wind volume for any given furnace, or for any group of furnaces, will be affected by other items than furnace design—type of metallic charge, quality of fuel, condition of the lining, and grade of



87 TANK BATTERY...

CURBS FIGHTING ACIDS AND SALT SOLUTIONS

. . . at temperatures to 360° Fahr.

ATLAS-Built Electro-plating Tanks in one of America's Newer War Production Plants

BUILT OF Reinforced Concrete, acid-proofed with lining of ATLASTISEAL Triple Layer Membrane, plus 4" brick lining, joined with

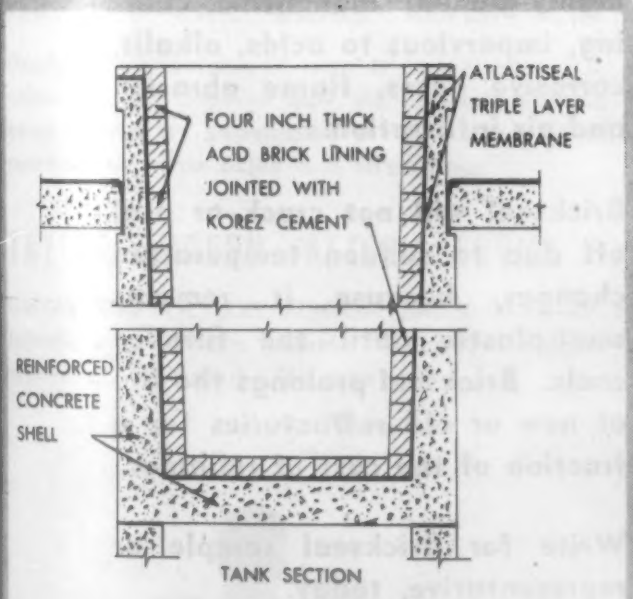
KOREZ—**A cement with remarkable properties**

INERT TO ACIDS—hydrochloric, lactic, phosphoric, acetic . . . of any concentration; and sulphuric, up to 50% concentration • ALKALIS—sodium carbonate, calcium, hydroxide, ammonia, etc., in dilute solutions • ALL FATS AND OILS, and most organic solvents.

NOT INERT TO nitric, chromic and hydrofluoric acids.

UNAFFECTED BY abrupt temperature changes; has high dielectric constant; resists abrasion and erosion; absorption about ¾ of one per cent.

KOREZ is used to join acid-proof brick in chemical equipment, such as tanks, vats, flues, towers, etc. and in laying tile, brick and masonry floors in chemical plants, food plants, kitchens, oleomargarine plants, soap factories, etc.



TANK SECTION

OTHER ATLAS ACID-PROOF CEMENTS . . .

KOREZ is one of five special acid- and alkali-proof cements. If you are planning acid-proof construction of any type, you will find valuable help in our Technical Bulletin TV-10A which will be mailed upon request made to our head office at Mertztown.

Technically trained ATLAS representatives may be reached at the addresses below • ATLAS offers *complete* acid-proofing service, including materials (readily available), proven design . . . and supervision of construction, if desired.

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*DENVER 2, Col., 1921 Blake St.
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*Stocks carried at these points

THE RITE PRODUCTS

are always the right products

FOR CLEAN STEEL

AND INCREASED PRODUCTION

LUNKE-RITE — an extremely effective exothermic, powdered compound for the control of piping in steel ingots poured *with or without*, hot tops; and in steel castings. It increases ingot yield considerably. The additional heat created has a beneficial effect on quality of steel by reducing rate of cooling in center section of ingot, which has been found to prevent internal cracks and laminations. This fact is especially important for large forging ingots.—Also used for fitting ladle stopper into nozzle;—as covering of nozzle and stopper head, which, as several plants claim, eliminate any dripping during the pouring;—as cover on steel in ladle where duplexing or reladling is practiced;—as cover on hot metal being transported a distance from blast furnaces.

A grade of LUNKE-RITE for every need.

RITE-MELT CLEANSER — a strongly effective powdered compound, containing no aluminum, placed on bottom of ladle just before tapping heat; or into stream as soon as it begins to flow into ladle; preferably on bottom of mold, thereby gaining greater advantage by preventing stool-stickers.

RITE-SULPHUR REDUCER — put on bottom of ladle just before tapping heat; or into stream as soon as it begins to flow into ladle. Reduction according to original content of Sulphur.

CONRAD WOLFF

Manufacturer—Owner of

THE RITE-PRODUCTS CO.

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Additional Products:

RITE-TONERDE — finest levigated alumina.

GREEN-ROUGE POLISH—levigated chromic oxide.

MILD POLISH—levigated tin oxide.

SHARP POLISH—levigated cerium oxide.

P. O. BOX 448 NEWARK 1, N. J.

iron being produced. Wind volumes varying from 180 cfm. per sq. ft. of hearth area to 60 cfm. are used successfully.

The gas velocity at the stock line, all other conditions being the same, determines the amount of dust that will be produced. Excessive pressure, or rather, excessive pressure drop through the furnace, even assuming that it does not immediately affect the furnace movement, eventually will cause an abnormal wear on the furnace lining.

The author is associated with an iron producer operating six furnaces varying in hearth size from 12 ft. 7½ in. to 21 ft. 0 in. Observation of the operation of these stacks indicates immediately that per unit of size the smaller furnaces produce a much greater tonnage of iron.

In regard to the matter of blast furnace production, the maximum normal capacity is often stated to be 2.45 net tons per sq. ft. of hearth per day. Many furnaces exceed that figure today, but it is interesting to note that the production measured with reference to hearth size increases as the furnace size decreases. On our six furnaces, all producing merchant iron with silicons largely from 2.00 to 3.00%, we note the following:

Furnace	*Hearth diam., ft.—in.*	*Net tons per sq. ft. of hearth per day*
1	12—7½	3.10
2	15—7	2.65
3	17—3	2.51
4	19—0	2.37
5	20—9	2.32
6	21—0	2.29

The best definition of blast furnace capacity was simply "what you can get out of them."

—E. L. Clair. *Iron & Steel Engr.*, Vol. 21, Apr. 1944, pp. 35-38.

Nitrogen Removal in Open Hearth

Condensed from "Stahl und Eisen"

For the removal of the nitrogen in the basic open hearth furnace, the duplex process with liquid charge from the Bessemer converter merits particular attention, as here the nitrogen content is high. The progress of the denitrification in the furnace as compared with the theoretically possible was investigated.

The efficiency of the removal of nitrogen, calculated as ratio of the average partial pressure in the carbon monoxide bubbles to the theoretically possible, indicates for the individual decarburization stages a strong decrease from specimen to specimen.

Carbon reduction velocity increases to about 0.2 at a reduction velocity of about 0.25% C per hr., and after this decreases only slowly with higher reduction velocities. This agrees with results obtained by H. Wentrop and W. Altpeter for denitrification in the electric arc furnace. The efficiency is probably somewhat lower for higher original nitrogen contents than for low ones.

During melting up to the first sampling, the efficiency is smaller, but also decreases with increasing decarburization velocity.

—W. Geller. *Stahl u. Eisen*, Vol. 64, Jan. 6, 1944, pp. 10-13.

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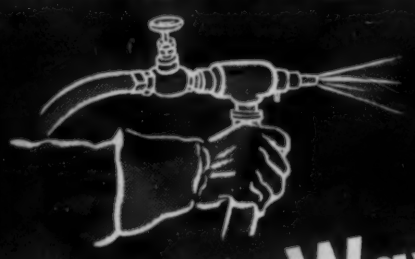

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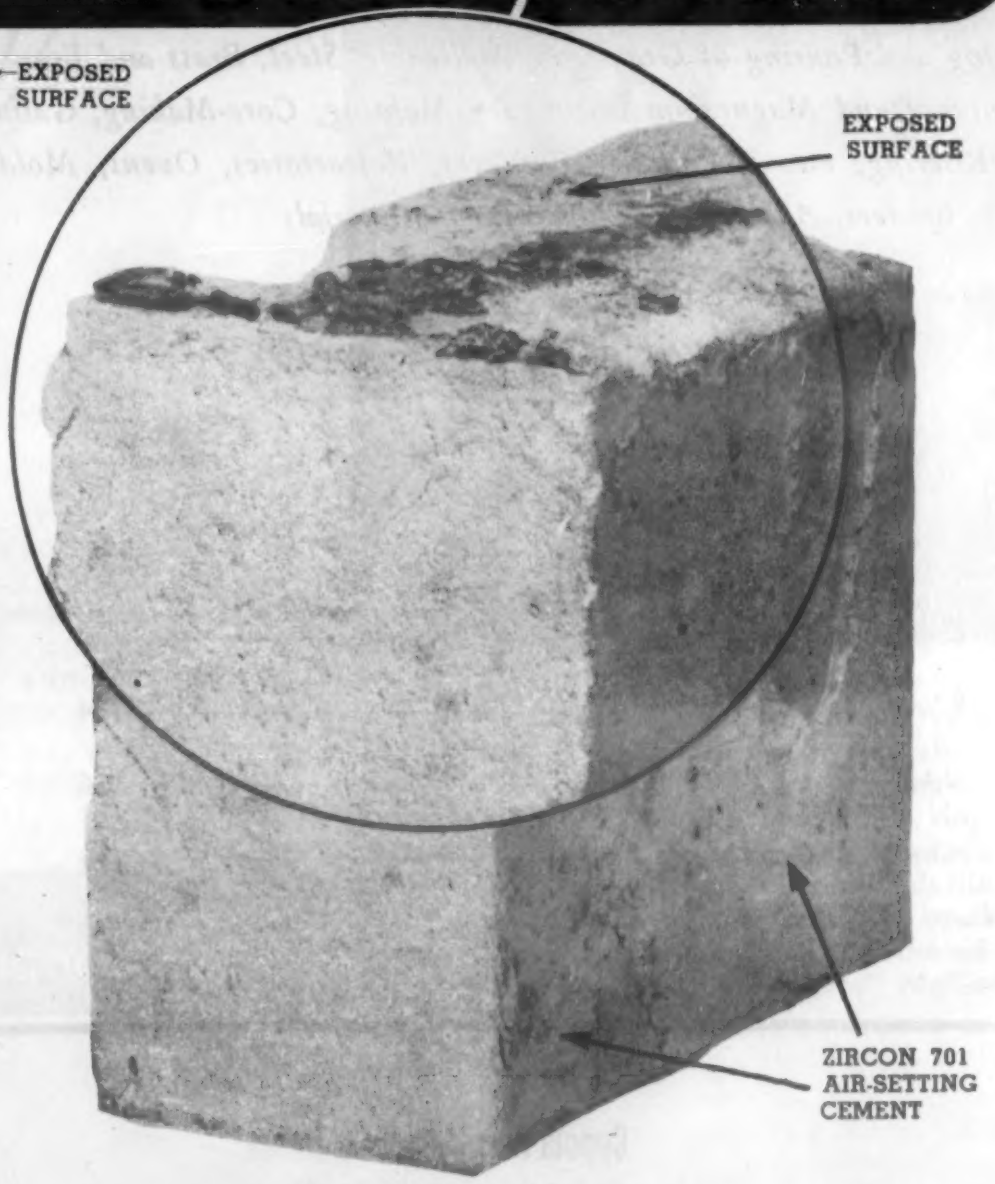

We think that these illustrations prove conclusively that, if the Refractory Industry ever developed a product which is unequalled, even uniquely fitted for one particular job, TAYLOR ZIRCON is certainly that product, when used for hearth construction in reverberatory type furnace for melting Aluminum.

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Cupola Raw Materials

Condensed from a Paper of the American Foundrymen's Association

The cupola used for cast iron melting is different from steel melting furnaces in its operation, control and limitations.

The term "heredity" was applied to steel to describe the particular characteristics of a given heat, which could not be explained on the basis of its chemical composition. This term has become meaningless with the development of present knowledge of deoxidation practice, hardenability, grain size control, and the influence of residual elements.

The accurate control of raw materials, by the steelmakers, has been an important factor in the elimination of the mysterious heredity as applied to steel.

In cupola melting, there is no opportunity for the "boiling," mixing and holding operations of steelmaking. It is, therefore, especially necessary to have control over the raw materials of the cupola. Certain constituents in very small amounts may have profound influences on the properties of the iron.

Hydrogen, which is largely obtained from the moisture in the air blast and with the cupola charge, is believed to have an important role in determining the properties of the iron. This factor is not well understood at present.

Coke is an important and variable raw material of the cupola. The properties and composition of a given coke are determined to a considerable extent by the coal from which it was made, and the coking practice employed.

Scrap, obtained from a number of sources, provides another highly variable raw material. The author recommends the development of a small briquetting device for chips, pointing out the economic unsuitability to the small shop of the large briquetting presses now on the market.

Briquetting Chips

E. R. Kaiser, of Battelle Memorial Institute, conducted experiments on the bonding of steel and cast iron chips with coke. This process is based upon the fact that certain coals become plastic in particular temperature ranges in the coking process. Kaiser demonstrated the feasibility of briquetting 75 to 85% of metallics by heating with 15 to 25% of coal at temperatures of approximately 1950 F., without the use of pressure.

Tests were carried out using these coke-bonded briquets in a baby cupola. The briquets functioned smoothly, producing "normal" soft iron, having a high sulfur content (about 0.20%). The first run was conducted using briquets containing steel and cast iron chips. Later runs with briquets containing steel chips exclusively were not successful in producing the desired carbon content in the iron. The product was a low carbon, low silicon white iron.

The chip-bonding process has excellent potentialities (which will require further investigation), *e.g.*, in malleable iron shops and generally in other small shops unable to afford a briquetting press.

Fluxes are currently used to clean the cupola and remove sulfur. It is believed that they could be used to perform other useful functions if other actions were more completely understood.

The author concludes with "getting a uniform product from the cupola out of this assembly of unknowns is an art rather than a science," and more control in foundry operation is badly needed in order to alter the picture.

—H. W. Gillett. *Am. Foundrymen's Assn.*, Preprint No. 30, Apr. 1944 meeting, 15 pp.

Silicon Bronze Castings

Condensed from "The Foundry"

The loss of the major source of Allied tin, the Dutch Asiatic supplies, has resulted in the increasing use of copper-silicon-zinc alloys as substitutes for tin bronzes. As a result of the increased use of silicon bronzes, some foundries that tried to apply to the founding of these alloys the principles used in the production of tin bronze castings encountered some difficulties.

Chief of these difficulties was the presence on many castings of surface irregularities, which were revealed on sandblasting. In one instance, a foundry pouring an alloy containing 4.80 Si, 13.70% Zn, balance copper had many rejects due to the presence of rough spots and powdery deposits on the surfaces of castings poured at 2200 F.

An analysis of the deposits showed about 90% zinc oxide and 10% silica. In an

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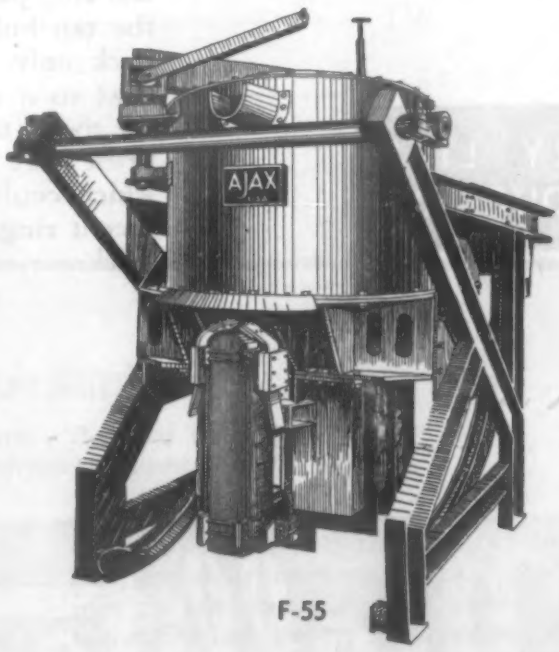

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effort to determine the causes of these deposits, a research program was initiated.

Difficulty was encountered in producing defective castings when the alloy was poured at 1750 F., although this temperature would normally be too low to run castings of tin bronze. Casting at 1900 F. and at 1900 F. after cooling from a temperature of 2350 F. also failed to produce defective castings.

However, when the metal was superheated to 2500 F. and cooled to 1900 F. for pouring, a condition similar to that encountered in production was duplicated. This indicated that proper control of superheating temperatures was of the utmost importance.

The use of pyrometers is essential because silicon bronze with its inherently higher fluidity must be poured at temperatures lower than those used in founding tin bronzes, and foundrymen accustomed to working with tin bronzes have a tendency to pour at too high temperatures if close pyrometric control is not exercised.

High pressure castings are being produced successfully in silicon bronze. The chief difficulties confronting a foundry starting to cast the alloy arise from the possibility of contamination and failure to compensate for the increased shrinkage inherent in this alloy. When proper precautions are taken, these two possible sources of trouble should be eliminated.

When silicon bronze castings are used as bearings, precautions must be taken to insure proper lubrication in order to prevent seizing. Lubricating oil must be used, as other lubricants, such as mutton tallow, are not satisfactory.

Silicon bronzes are no more susceptible to gassing than tin bronzes or red brasses. Open flame furnaces are satisfactory for melting, and the alloy should not be heated above 2000 F. during melting operations.

—R. J. Keeley. *Foundry*, Vol. 72, May 1944, pp. 62-64, 162, 164.

Non-Ferrous Cupola Melting

Condensed from a Paper of the American Foundrymen's Association

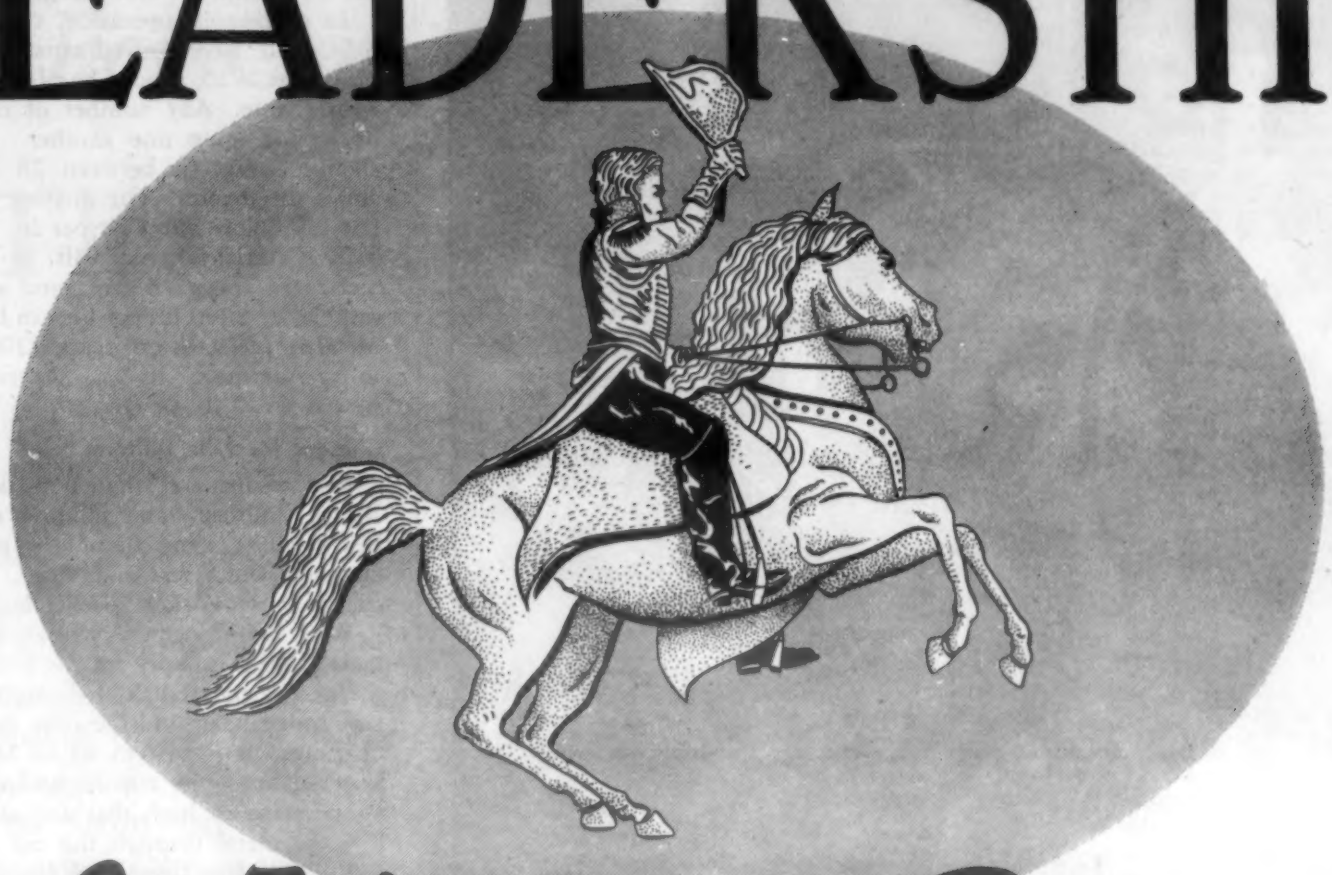
A specially constructed cupola has been used by large brass foundries in recent years to maintain highly mechanized molding production. The fuel has been important, a coke from coal-tar pitch that is 99% C.

The cupola has a 42-in. shell line down to 26 in. Shell and stack (20 ft. above charging door) are lined with fire brick. An inner brick of silicon carbide extends from the base to 28 in. above the tuyeres. A constant volume or positive displacement blower equipment with air-weight control is preferred.

Tuyere openings, tap hole and rear knock-out opening are cut out after the entire inner lining has been rammed in place. A 24-hr. wood fire will dry out and "set" the lining.

In preheating, it is important that the

LEADERSHIP



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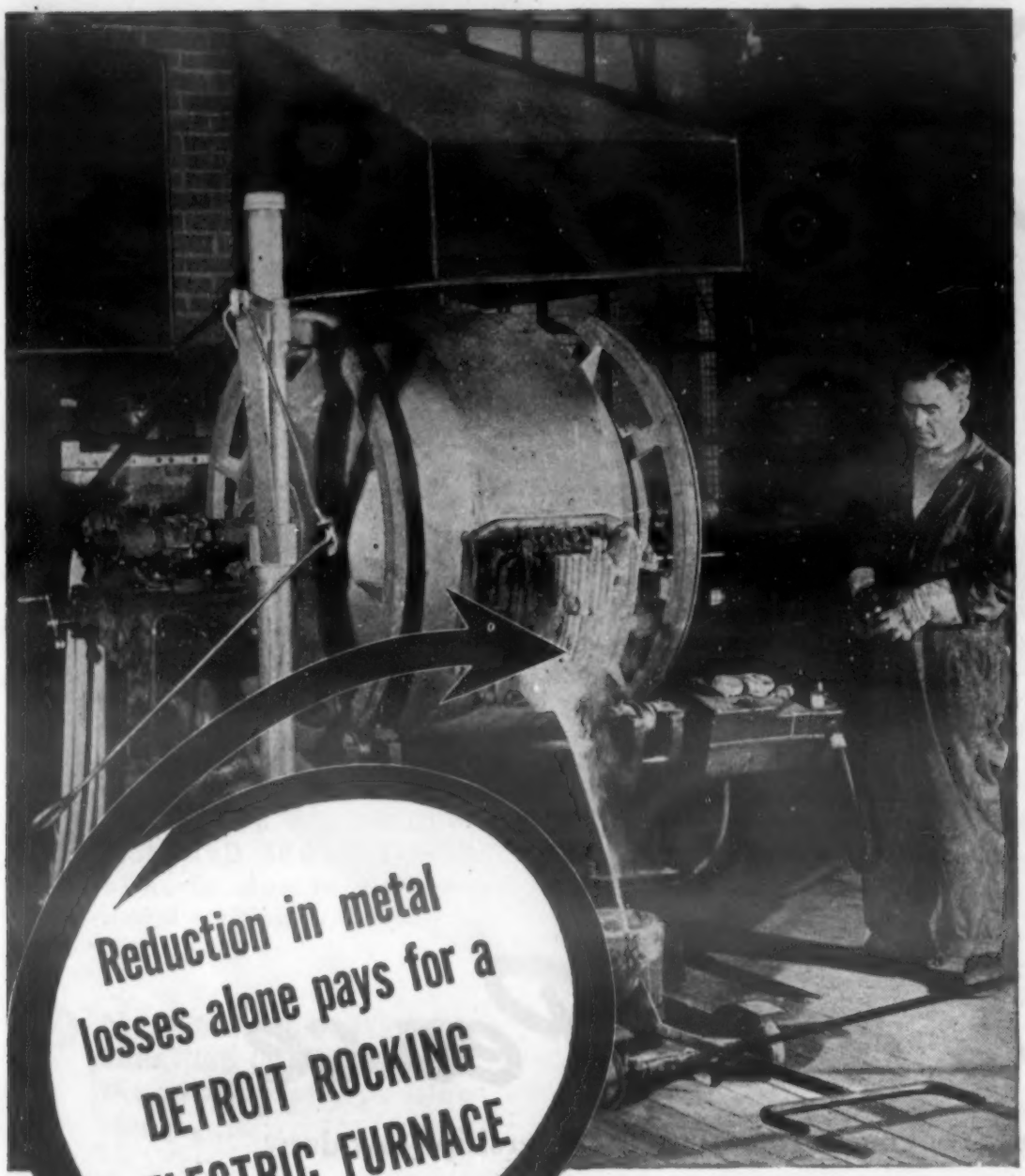

A well-known manufacturer of valves and plumbing goods wrote recently, "Eight years experience with a Detroit Rocking Electric Furnace has convinced us that it is the most effective and economical equipment for melting brass. Tests show that we have reduced our metal losses 65%. Even if our Detroit electric Furnace showed no other savings (which it does) we figure that we save 500 tons of brass a year which is enough to write off our investment in the furnace in one year."

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linings below the tuyeres and the bottom be well heated, otherwise the initial charge passing through the furnace will be cold. The bed should be incandescent through to the top before the first charge is introduced.

In continuous operation, charges of 400 to 450 lb. have proved satisfactory. Coke, ratioed at 1:20, should be placed on top of each charge. Any number of charges may be lapped upon one another. Bed height should always be between 28 and 36 in. above the tuyeres. The melting rate should not fall below 2500 lb. per hr.

The initial charge will be completely melted in about 13 min., and a maximum capacity of 6000 lb. per hr. can be obtained. Metal in the stack can reach 2200 lb., equal to five or more charges. Average production is 4500 lb. per hr.

Charges Must Be Uniform

Best results are attained by keeping the charges uniform, and holding the borings below 30%. Sand should be removed off all gates and risers and scrap. The entire charge must be pre-alloyed metal.

With uninterrupted operation, one can melt at peak capacity for 16 hr., but where there are shutdowns and metal changes, slag congeals around the coke at the tuyere openings. It is best to let no slag-forming material enter the cupola, and to keep the temperature so high that any slag can follow the metal through the tap hole.

Volatilization losses will range from zero for copper to 60% for a zinc content of 3 to 6%. Changing from one alloy to another requires about 30 min. The first 200 lb. of changed metal should be pigged.

This cupola can be used for melting high lead alloys (over 15%), but one must be very careful to maintain uniformity of the furnace operation.

When the furnace has drained completely, the air supply is shut off and the hinged bottom is dropped. The blocks are removed from the rear opening, the bed is poked and broken loose, and all slag and coke adhering to side walls are removed. The lining can be chipped out and patched after 8 hr. A monolithic lining is better for patching than one of brick.

The melting of copper alloys in a cupola is rapid and economical, especially where an uninterrupted supply of metal is required. Melting loss is low and the product is clean and of high quality.

—Leighton M. Long, *Am. Foundrymen's Assn.*, Preprint No. 44-8, Apr. 1944 meeting, 7 pp.

Aluminum Gravity Die Castings

Condensed from a Paper of the American Foundrymen's Association

Of one hundred and thirty castings on the Merlin engine, made by Rolls-Royce Ltd., one hundred and three, or 80% of the total, are produced as gravity die castings. The reasons for the extensive use of gravity die castings may be summarized as follows:

(1) Smoother finish and closer dimensional accuracy; (2) greater speed of production; (3) conservation of raw materials;

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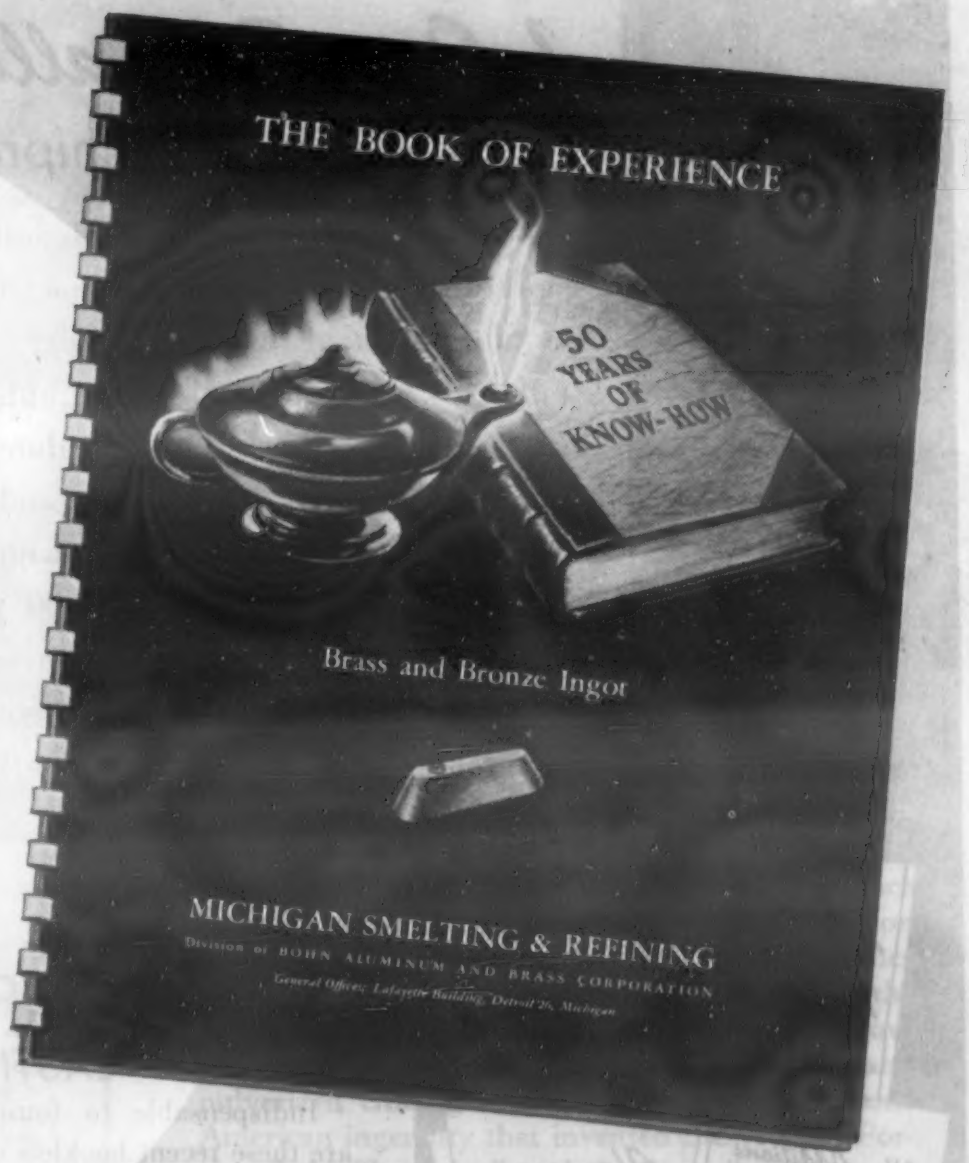
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(4) reduction of production scrap; and (5) improved mechanical properties in the casting.

Although the cost of the die is frequently greater than that involved in production of pattern equipment for sand castings, it has been found that the increased cost may be written off by the difference in cost of castings, if the quantities involved are sufficiently great.

When the design department has decided a given casting can be made by gravity die methods, a die is designed according to the latest specifications and drawings and is then turned over to the experimental die foundry for tests. If the rejects are below a maximum of 5%, the die is accepted for production.

In case any defects are discovered by radiographic inspection, or if any are due to the action of the die, such as ejector mechanism, which might cause distortion in castings during removal, the die is sent back for modification and design changes.

Wherever possible, the use of sand cores is avoided because of the extra machining and reduced quality of surface. Surveys have shown that the use of die casting methods in place of sand castings has resulted in labor cost savings ranging from 20 to 60%.

In the production foundry, melting is done in a battery of five producer-gas fired tilting furnaces of 500-lb. aluminum capacity. After degassing, the metal is transferred to smaller holding furnaces, which act as a reservoir for the die-casters. All transfer of metal is by means of overhead monorail conveyors.

Dies Prepared for Pouring

Dies are carefully cleaned, dressed and pre-heated before each pouring operation. During pouring, close attention must be paid to pouring time, and cooling time must be sufficiently long to prevent cracks and failures during removal from molds. The castings are sent to the core knockout tables in the care of semi-die castings, and then to the visual inspection station.

Castings that pass the visual inspection are sent to the band sawing section where gates and risers are cut off on band saws. Following this operation, the castings are subjected to the chalk test. Here the castings are immersed for 14 to 20 min. in oil at about 190 F., and after draining are dried in sawdust. The castings are then dusted with french chalk.

If any cracks are present, they will have expanded when immersed in the hot oil and the oil will have penetrated into the voids. On cooling, the oil is forced out of the cracks and discolors the french chalk.

All castings that pass the chalk test are sent to the final cleaning room, where fins and flash are removed by high-speed files. The castings are then given pressure tests where needed and dimensional checks.

Accepted castings are solution tested and aged in forced-air-circulation furnaces of the batch types. Quenching from solution treatment is done in water at 194 F. Aged castings are air cooled.

Spectrographic analysis checks quality of material, and periodic radiographic examination of castings selected at random checks the quality of the finished castings.

—John Vickers. *Am. Foundrymen's Assn.*, Preprint No. 3, Apr. 1944 meeting, 60 pp.

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Gas Pickling of Steel

Condensed from "The Iron Age"

Development of gas pickling to remove oxides and other surface impurities from steel strip as vapors was a natural way to apply information and experience gained in the use of controlled atmospheres from previous applications. In galvanized sheets prepared by gas pickling before being coated, not only were blisters non-existent, but the coating was more adherent, and superior to the product obtained when the same coating practice was applied to a wet pickled sheet.

Gas pickling removes oxides on steel by converting them into vaporized chlorides by reaction with hydrogen chloride gas at elevated temperatures. Reaction may be carried out in a gas-tight externally-heated chamber composed of chromium-nickel iron alloy, or in a refractory-lined internally heated chamber.

Application of the process to strip steel is similar to the conventional atmosphere furnace applications. The strip is uncoiled and passed into a preheating furnace where oil is burned off and the strip is simultaneously heated to the pickling temperature (1100 to 1350 F.).

From the preheat furnace it passes through an atmosphere seal into a muffle. Here the gas flows counter to the strip. After this the strip enters a cooling zone, passes through a liquid seal and into the air.

The typical reaction that takes place during combustion of methane with chlorine and air is $CH_4+2Cl_2+5\left(\frac{O_2+4N_2}{5}\right)=4HCl+CO_2+4N_2$. By controlling the proportions carefully, water vapor may be excluded from the end products of combustion. Similarly, the reducing gas—carbon monoxide, or oxygen—may be obtained, depending upon the proportions used.

Proportions necessary for a given fuel gas can be calculated if the analysis of the natural gas is known. Composition of the atmosphere obtained by burning a 1000-B.t.u. natural gas with chlorine and air is usually about 40 HCl, 10% CO_2, the remainder nitrogen. This chlorine burner gas is diluted with an equal amount of dehydrated flue gas. The dry atmosphere introduced into the muffle will be about 20 HCl, 10% CO_2, remainder nitrogen.

No Preheating Required

Strip may be passed into the muffle without preheating, thus avoiding formation of any more oxide. However, it is preferable to heat strip to the reaction temperature in a furnace designed for fast heating and then pickle the strip after it has reached the reaction temperature in a separate furnace.

Preheating by direct flame application is much more rapid than indirect heating, and is more economical. It forms additional oxide, but is very desirable because it burns off oils and other compounds that may be on the surface.

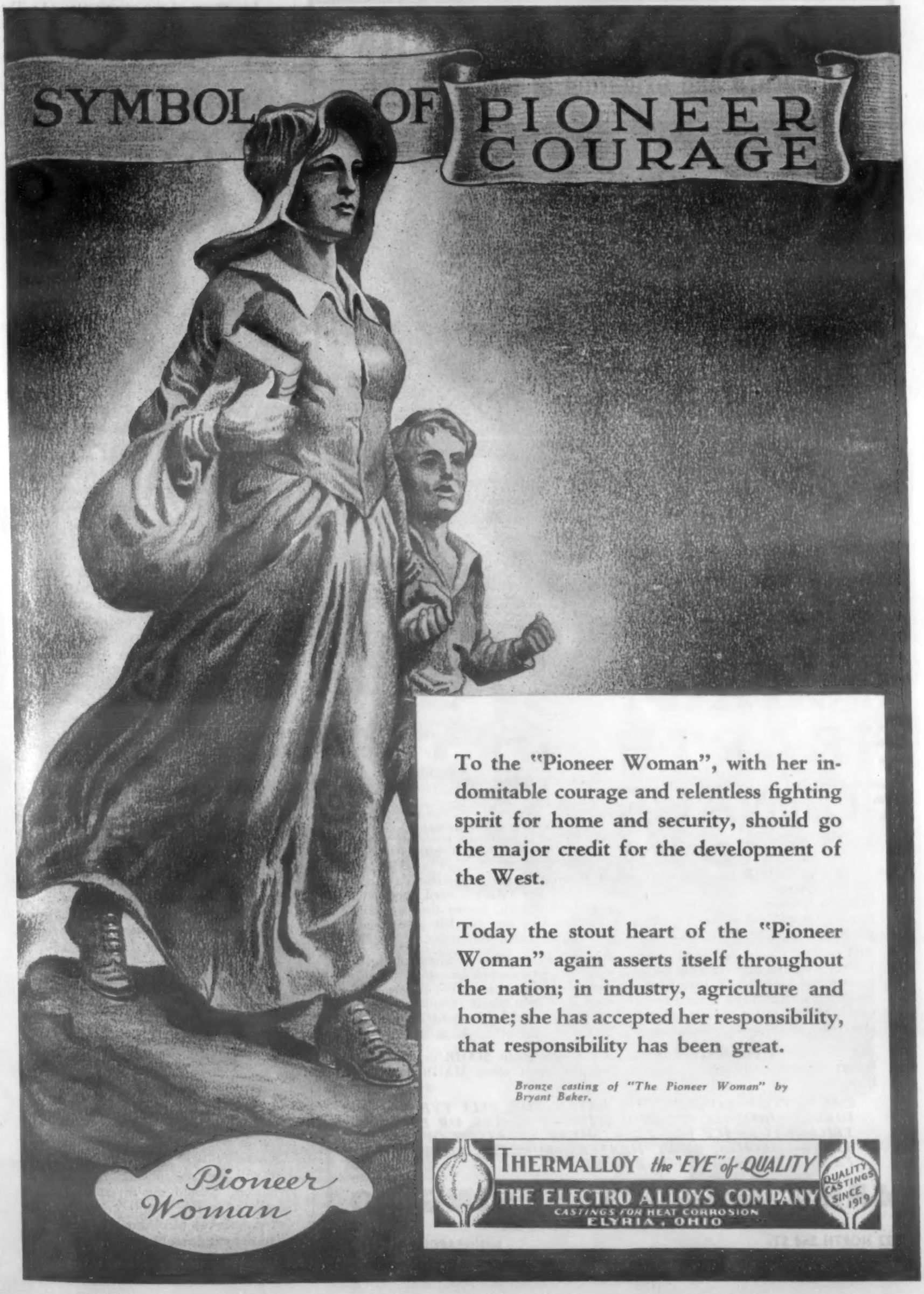
The pickling chamber, or muffle, is composed of a heat-resisting alloy of chrome-12 nickel variety, and is heated externally. The furnace is capable of holding temperatures of 1000 to 1350 F. Since the reaction is practically heat balanced, the gas pickling furnace is merely a heat holding furnace.

Waste gases that have been formed cannot be vented until the ferric chloride and hydrogen chloride have been removed. Ferric chloride is removed by washing with water, and the remaining gases are passed through a water absorption tower to remove remaining hydrogen chloride. Since air is to be excluded from the reaction chamber, charge and discharge seals are required. The whole system is put under a slightly subatmospheric pressure.

As the strip leaves the pickling chamber, it is passed through a cooling zone where a small flow of pickling gas protects the steel against reoxidation. It is cooled so that it may be passed through a liquid seal.

Since the line runs on a constant tonnage basis, the speed of the strip for 0.025 in. material would be twice the speed of strip when operating on 0.050 in. material. The number of sq. ft. of surface of light gage pickled at constant tonnage would be double that for heavy gage material. The pickling time varies from 10 sec. for light gage to 1 min. for heavier gage.

SYMBOL OF PIONEER COURAGE



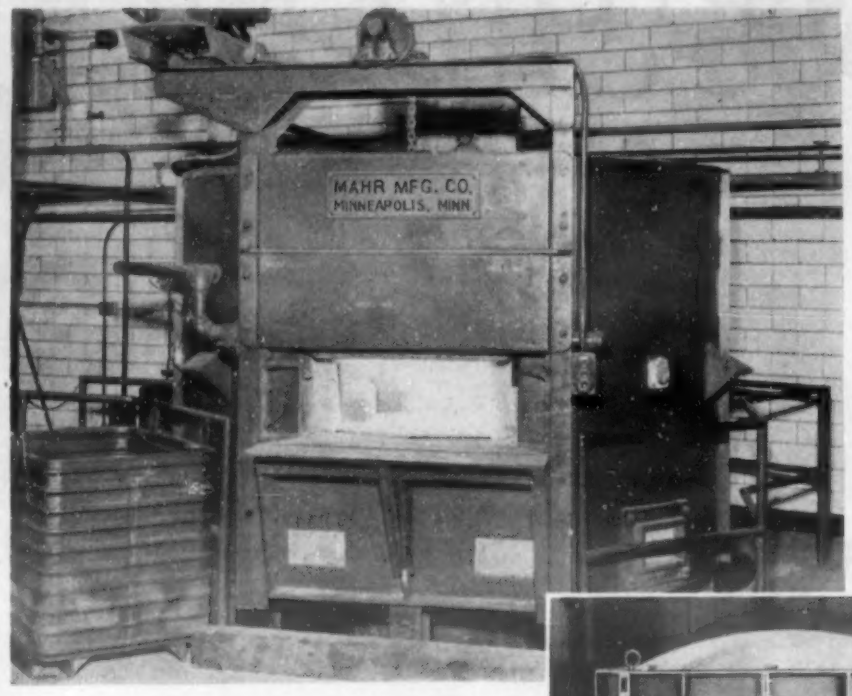
To the "Pioneer Woman", with her indomitable courage and relentless fighting spirit for home and security, should go the major credit for the development of the West.

Today the stout heart of the "Pioneer Woman" again asserts itself throughout the nation; in industry, agriculture and home; she has accepted her responsibility, that responsibility has been great.

Bronze casting of "The Pioneer Woman" by Bryant Baker.

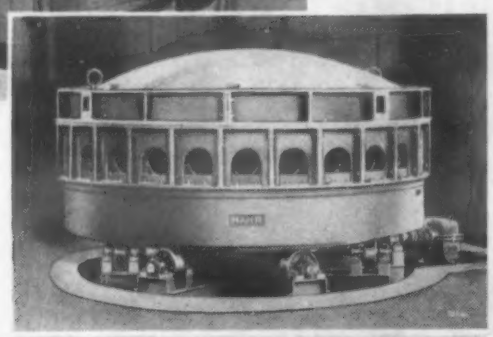
THERMALLOY *the "EYE" of QUALITY*
THE ELECTRO ALLOYS COMPANY
CASTINGS FOR HEAT CORROSION
ELYRIA, OHIO
QUALITY CASTINGS SINCE 1919

STARTLING REDUCTIONS
in decarb and oxidation of forging billets



(Left) MAHR Center Fired Rotary Hearth Furnace. One of a battery of these furnaces in the very modern forging plant of a large midwestern manufacturer.

(Below) MAHR Rotary Nosing Furnace used for heating the nose of high explosive shells. Continuous, high production is characteristic of this center fired rotary. In this furnace, however, the entire furnace rotates.



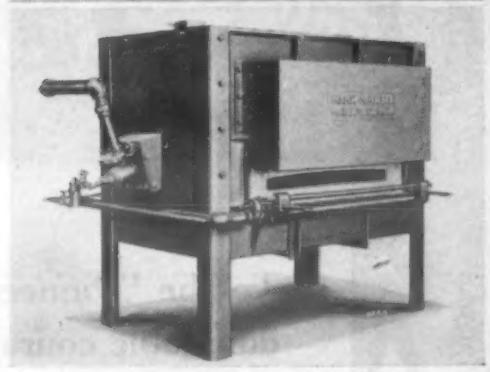
in the

MAHR

ENGINEERS • DESIGNERS • MANUFACTURERS
ALL EQUIPMENT FOR METAL HEATING

Center Fired

ROTARY HEARTH FURNACE



A modern MAHR Slot Type Stationary Forging Furnace. Fires toward and with arch from both sides. Illustrated and described in Bulletin No. 210.

As in other MAHR furnaces, the method of firing is the fundamental reason for the outstanding success of this furnace. Only one burner is used, therefore burner adjustment is simplified. This powerfully efficient burner fires upward directly toward the arch. The flame wipes the arch and the hot gases flow downward over the entire hearth area giving remarkable uniformity.

And here's the most important point—because of this method of firing, the fuel has time for *thorough combustion* before the hot gases reach the stock. Combustion has rendered all harmful gases practically harmless before they could reach the stock. Thus, decarb and oxidation have been nearly eliminated. One extensive user states decarb and oxidation are reduced by from 65% to 75% over other methods of heating.

Ask for Bulletin No. 1000 giving complete details about MAHR *center fired* Rotary Hearth Furnaces, or Bulletin No. 210 about other MAHR Forging Furnaces.

CAR BOTTOM, CONTINUOUS, BATCH, POT, BELL TYPES—DIRECT FIRED OR RECIRCULATING—OIL, GAS, OR ELECTRIC—A FURNACE FOR EVERY HEAT TREATING OPERATION—TORCHES, RIVET HEATERS, BURNERS, BLOWERS, FANS, VALVES. ASK FOR BULLETINS.

MAHR MANUFACTURING CO.

Division of Diamond Iron Works, Inc.

1722 NORTH 2nd ST. MINNEAPOLIS 11, MINN.

Advantages of the process are: (1) The surface is cleaned without gas absorption by metal; (2) oxide can be removed very quickly, and basis metal can be etched to any desired degree; (3) preferred surface for the application of protective coating is obtained; (4) economics of process compare favorably with cost of acid pickling; (5) no degreaser is needed; and (6) annealing and pickling is accomplished as a single operation.

—J. J. Turin. *Iron Age*. Vol. 153, Apr. 20, 1944, pp. 64-70.

Servicing Welder Controls

Condensed from "Welding Engineer"

Ignitrons have eliminated most of the disadvantages of the mechanical contactors for spot and seam welding. They have no moving parts, and are enclosed in oxygen-free tubes. The ignitron circuit consists of an enclosed pool of mercury, which serves as cathode, while a graphite anode is supported on top. One ignitron will pass alternately ½ cycle a.c. current to the welding transformer primary as long as the ignitron circuit is energized. When two ignitrons are connected in inverse parallel, one tube will carry the positive and the other the negative ½ cycle so that the welding current is continuous.

For precision welding, thyratron tubes are used to control the ignitor circuit. Thyratrons, under normal conditions, are rendered non-conducting by applying a negative voltage to the grid. If positive voltage is superimposed on the grid, current will flow from cathode to anode of the thyratron.

For proper operation, the ignitron demands a minimum load under which it will function, which is about 40 amps. Electrodes must be closed before ignitrons are fired.

Often electronic control is checked when the trouble lies solely with the welder. On a cam-operated press type welder, for example, the operator cleans and refaces tips without making adjustments for the removed material. Another condition on a cam-operated machine may arise when the timing cam is out of time, causing it to fire either too early or too late. In either case the work will be damaged.

Contact surfaces must be kept clean. The best method is to adhere to a regular cleaning schedule. Other troubles are broken wires, open resistor causing an inoperative timing circuit, or overheating of copper rectifier. An ignitron, in rare cases, may conduct current through the welder without action of the ignitor circuit. This indicates that the tube is filled with gas.

A 6- to 10-amp. fuse is used in the ignitor circuit. Such a fuse protects the thyratron in case of a broken-down ignitor.

A d.c. millivolt meter with zero center scale will indicate either bad ignitrons or thyratrons. Should the thyratron be near the end of its life, it will work erratically.

A cathode-ray oscilloscope is often helpful in detecting trouble.

—E. Stolte & R. Washburn *Welding Engr.* Vol. 24, May 1944, pp. 45-47.

Here's a great small spotwelder that is

★ *sturdy...*

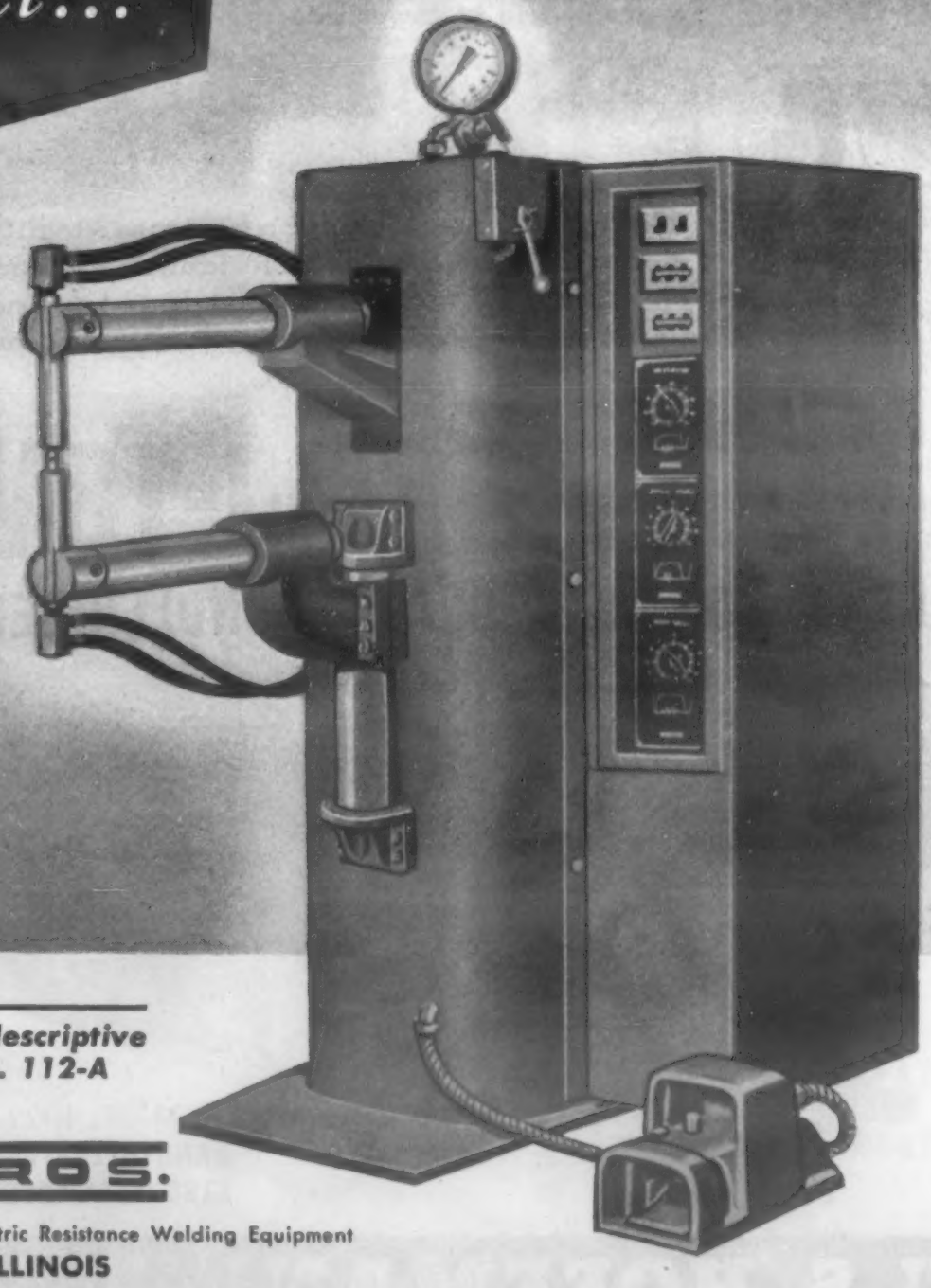
★ *precise...*

★ *fast...*

★ *compact...*

SCIAKY engineering has proved that it is possible to make a machine that is small, yet capable of delivering fast, high quality spot welds in day in and out production. Incorporated in this rocker arm type welder are exclusive features hitherto only used in larger machines. The use of heavy duty roller bearings at the fulcrum point of the arm, together with a special rubber cushion in the pressure cylinder, assure smooth action . . . eliminate hammering and wear. The design is compact with controls and contactor in a hinged cabinet . . . dials are convenient to operator and unit may be easily installed or moved.

If your problem involves the fabrication of mild, stainless or zinc-coated steels and brass in light gauges, it will pay you to consider the "PMCR.0-1."



MODEL PMCR.0-1

Rated 30 KVA at 50% duty cycle for power supply of 440 or 220 volts, 60, 50 or 25 cycles. Capacity: clean mild steel from two thicknesses of .016" up to and including .080"—stainless steel up to a maximum of .040" plus .040". Speed on two thicknesses of .032" thick pickled mild steel is 180 welds per minute. Maximum electrode pressure at 24" throat depth is 1000 lbs.

Write for descriptive bulletin No. 112-A

SCIAKY BROS.

Manufacturers of a Complete Line of AC and DC Electric Resistance Welding Equipment

4915 W. 67TH ST., CHICAGO, 38, ILLINOIS

In England: Sciaky Electric Welding Machines, Ltd., London

Branch offices in Detroit and Los Angeles

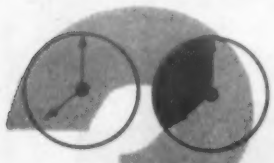
SAVE 3 WAYS!

1 MEN

A smaller maintenance crew can service a larger number of machine tools when Hoffman coolant conditioners are on the job. Hoffman filters continuously deliver waste solids in dry form for easy disposal.

2 MONEY

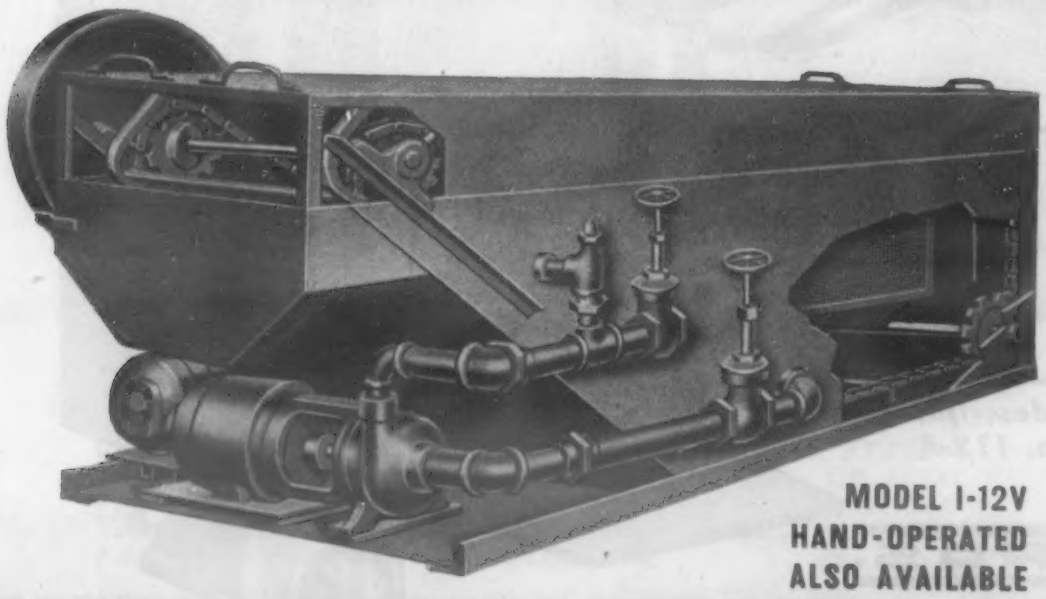
Hoffman Model I-18V self-cleaning coolant conditioners effect large savings in maintenance, in coolant replacement, in longer life for machines, cutting tools and grinding wheels, and in fewer rejects.



3 MINUTES

'Round-the-clock operation becomes a reality. Hoffman filters eliminate shutdowns for sump cleaning, add more productive time to grinding machine operation, frequently permit faster operating speeds.

WITH HOFFMAN I-18V SELF-CLEANING COOLANT CONDITIONER



MODEL I-12V HAND-OPERATED ALSO AVAILABLE

U. S. HOFFMAN MACHINERY CORPORATION
223 Lamson St., Syracuse, N. Y.
COOLANT FILTERS · FILTRATION ENGINEERING SERVICE

Cold-Conditioning of Abrasives

Condensed from "Metal Finishing"

For years greaseless abrasive compounds used in the plant with which the author is associated were regularly kept in an ordinary ice refrigerator for the purpose of preventing excessive evaporation of volatile constituents and consequent hardening of the compound.

However, in hot humid weather difficulty was always experienced by the operators in making the compound adhere to the buff. Also, excessive time was required for the compound to harden on the buff, and waste was abnormally high.

Favorable results on elimination of the above difficulties were obtained on a small scale by refrigerating the compound with dry ice at a temperature of —20 F. At this temperature the compound becomes extremely hard, and on applying to a rotating buff it adheres "like magic."

Encouraged by this result, an electrical refrigerator capable of chilling a day's supply of compound from room temperature to —20 F. in 14 hrs. was purchased. An illustrative calculation which is given shows that for 500 lb. of compound, a refrigerator having a thermal capacity of 25,000 B.t.u. in 12 hrs. (and sufficient volume to hold the compound) is required.

Production records showed that after installation of the refrigerator, consumption of abrasive compounds was reduced by 37%, making possible the amortization of the refrigerating equipment in 3 months, based on continuous use at near capacity level. Other advantages are cleaner working conditions and accelerated production.

No study was made to determine whether —20 F. was an optimum temperature. Since it worked well it was used.

—H. Seman Payne. *Metal Finishing*, Vol. 42, Jan. 1944, pp. 10-11.

Spray Painting Railway Equipment

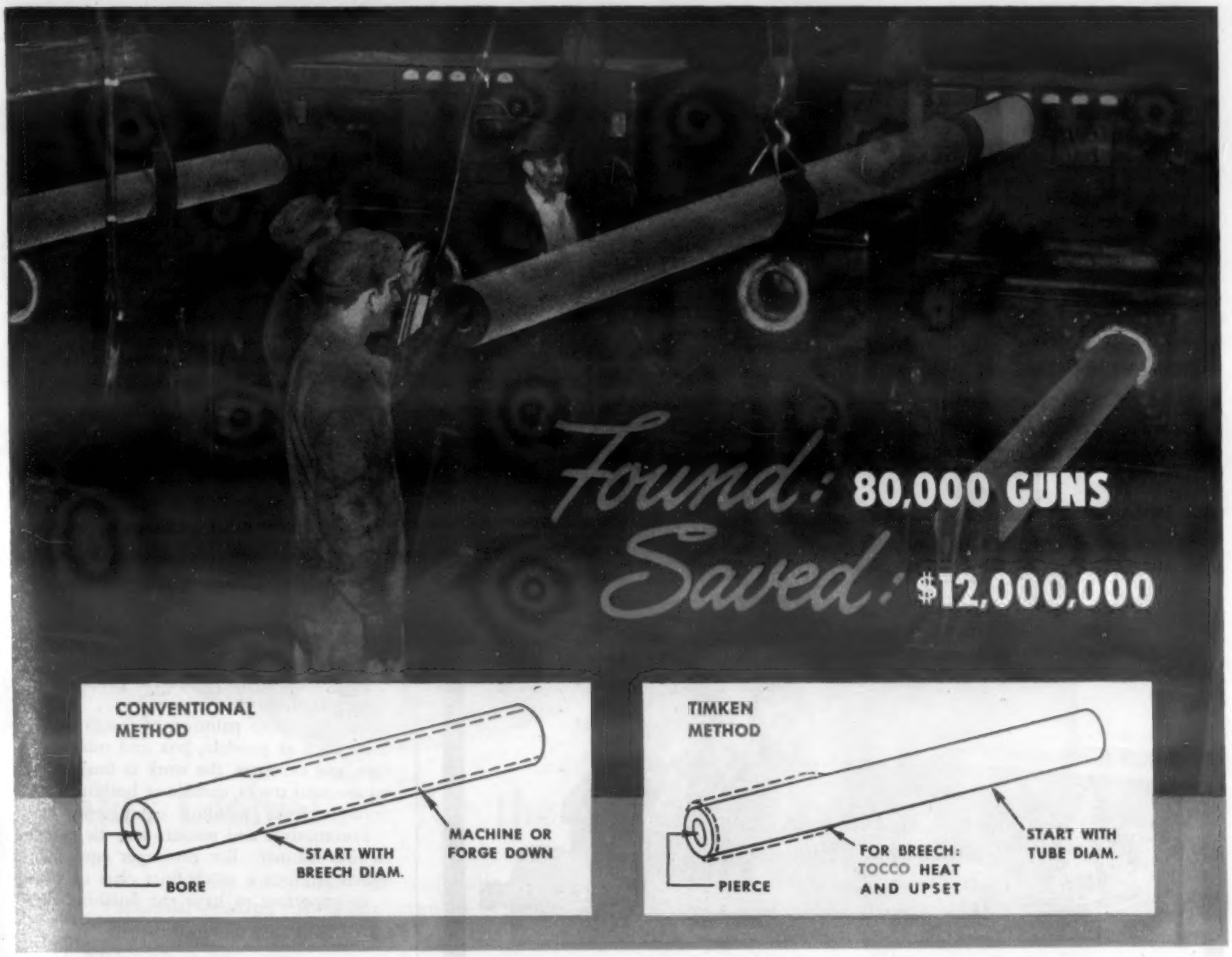
Condensed from "Railway Age"

The advantages of improved quality of work and economies in time and cost of spray painting have led to its adoption for the painting of almost every type of equipment and structure. Spray painting may be done in about 1/5 to 1/3 the time it takes for brush painting, depending on the surface being finished.

Paints, varnishes, enamels, lacquers, oil stains and similar materials, however, are inflammable and, when discharged from a spray machine in a finely atomized form, may create a fire hazard.

It is obvious that all precautions should be taken in the design of facilities for spray painting railway rolling stock and that every safeguard against fire hazard be provided. A ventilating system should be installed that will positively drive fumes away—the system should be as nearly perfect as practicable.

All spray-painting buildings and enclosures should be constructed of non-combustible materials, and the interiors kept well painted or otherwise coated and clean. Numerous other precautions must be taken.



WHEN war came to the U. S., we faced a bottleneck in forging and machining to produce bofors and heavy guns for tanks, airplanes by the conventional method. Had it not been for Timken Roller Bearing Co.'s development of a new way to make gun barrels from seamless steel tubing, serious shortages in arms would have occurred at a critical time.

TOCCO Induction Heating plays a vital part in this new method (see sketches), affording accurate, localized heating, essential for uniform upsetting of the tube to form the gun breech. Speed of heating practically eliminates scaling, minimizing wear on dies.

By this speedy method, Timken Ordnance Co. produced more heavy gun tubes per month than England turned out in two years up until April 17, 1942. In less than 2 years, the plant added 80,000 75 m.m. and 40 m.m. gun barrels to Allied strength and did this at a saving of $12,000,000 over the former method.

Four TOCCO Inductors, powered by two 200 K.W. TOCCO JRS. heat the entire output. End of 75 m.m. tube (7″ o.d., 2⅜″ i.d.) is heated for a length of 18″ to 2350° F. End of 40 m.m. tube (4¾″ o.d., 1¼″ i.d.) is heated for 15″ length to 2350° F.

Find out how the speed, economy and uniformity of TOCCO can aid *your* war production and post-war strategy. "Results with TOCCO" free on request.

THE OHIO CRANKSHAFT COMPANY • CLEVELAND, OHIO

TOCCO

HARDENING..BRAZING

ANNEALING..HEATING

ROTOBLAST

SIMPLIFIES BLAST CLEANING

★ Airless **ROTOBLASTING** — simplifying work in so many war plant cleaning departments today—multiplies blast cleaning speed many times over. The *reason why* lies in higher abrasive speed and impact, less delays and greater production possibilities when the **ROTOBLAST** unit is incorporated into Barrels, Tables and Cabinets adapted to fit your requirements.

The Pangborn **ROTOBLAST** is designed to do a **BIG JOB** with *little* effort. This means a cleaning department reduced to one operator for two machines, with an unskilled laborer for help in loading and unloading. Gone is the high labor overhead with its uncertain human factor Cleaning speed becomes regular, certain, predictable. Costs are down. Production is up.

ROTOBLASTED work is free from sand and scale. **ROTOBLASTED** work is easier to grind and machine. Therefore tools last longer. **ROTOBLASTED** work has fine uniform appearance.

For ECONOMY—SPEED—SATISFACTION—use **ROTOBLAST.**

BARRELS • TABLES • CABINETS

PANGBORN

WORLD'S LARGEST MANUFACTURER OF DUST COLLECTING AND BLAST CLEANING EQUIPMENT

PANGBORN CORPORATION · HAGERSTOWN, MD.

Forced ventilation should be provided with ample fresh air inlets for supplying clean, preferably filtered, air. Exhaust stacks or piles should lead to the outside air direct and not through other rooms. All solvents, paints, lacquers and other such inflammable liquids must be stored and mixed in rooms separated from the spraying operations.

The primary equipment required for spray painting consists of an air compressor, air receiver, motive power and accessories, one or more spray guns, material containers, etc. There are several methods for the attainment of proper spray painting conditions:

1. By a down draft carrying all excess spray, vapors, etc., through grills in the floor and through stacks, directly or through a water spray, to the outside.

2. By confining the paint vapors with a cabinet-type spray booth from which they are drawn directly or through a water spray to the outside.

3. By carrying the vapors and residues up through an overhead canopy leading to stacks through the roof. This is done by a combination of exhaust fans in the canopy stacks and a forced draft from slots in the floor. This is the type most frequently used in car shops for painting passenger equipment.

For the spray painting of freight equipment such as gondola, box and refrigerator cars, and cabooses, the work is finally done on assigned tracks, outside of buildings with portable spray painting equipment.

Locomotives and tenders may be painted in like manner. For passenger equipment, which requires a much finer class of work, it is important to have the finishing done indoors.

—*Railway Age*. Vol. 116. Apr. 29, 1944, pp. 809-811.

Stretch-Forming Metal Sheet

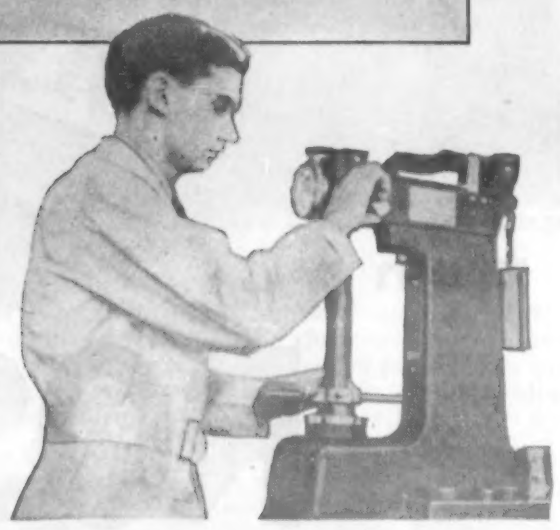
Condensed from "Steel Processing"

Stretch-forming is a process of forming sheet metal into a curved surface by clamping the sheet at two opposite edges and forcing a punch of the desired shape into the taut sheet. There are two limiting conditions in the application of this process: (1) Tearing or rupturing of the sheet before it has been stretched over the entire surface of the punch; this limitation is a function of the ductility characteristics of the metal being formed; and (2) buckling of the sheet due to compressive stresses transverse to the direction of restraint.

In order to understand and, in some cases, eliminate wrinkling, it is desirable to make a qualitative stress analysis of a sheet subjected to the stretch forming process. Qualitative analyses are made of a concave cylindrical part, a double concave part, a convex cylindrical part, and a convex concave part, as well as a quantitative analysis of the latter.

It is concluded that there are two distinctly different sources of transverse stress during stretching: (1) The variation of longitudinal tensile strain across the width

The Most Important Thing To Look for in Resistance Welding Electrodes is Something You Cannot See . . .



Quality Control . . . for the Right Alloy, Correctly Produced

Prescribing the proper electrode alloy for a specific welding job is important. Even more important is the ability to make that alloy so that its composition never varies in process of production.

Here at Mallory we have mastered the art. We know how metallurgical processes affect our alloys. We know what physical and electrical properties they impart. And we duplicate them again and again through a rigid system of quality control.

This thorough and scientific regulation starts with the raw materials. It continues through every detail of operation to the finished tip, roll or die. It follows the finished product into your plant, checking on performance in actual operation. It includes hundreds of sample melts in experimental furnaces, Rockwell tests for hardness, microscopic examinations for grain size, repeated alternating stresses in fatigue machines, elastic limit determination, exact measurements of tensile strength, electrical and thermal conductivity.

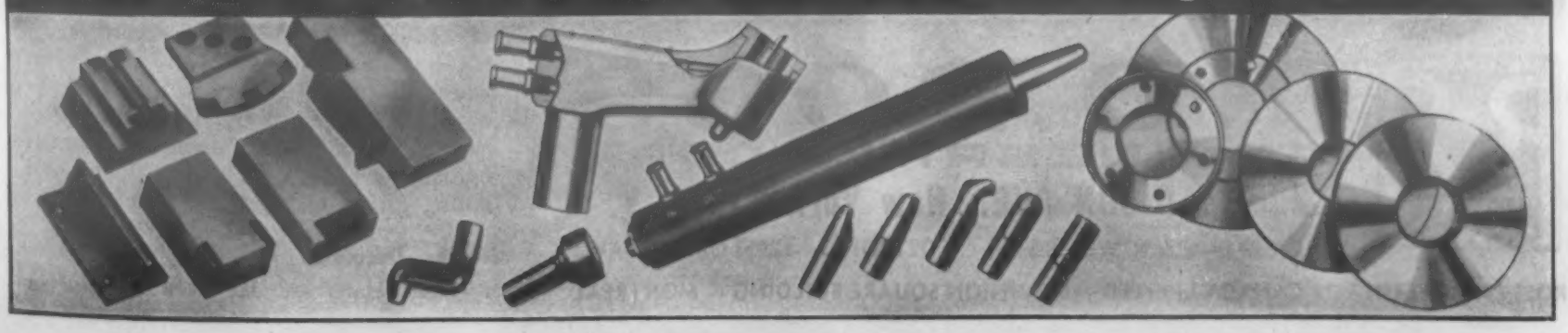
With such attention to detail, it is possible for you to establish high speed set-ups and procedure which, once fixed upon, require little if any change. Write today for specific data.

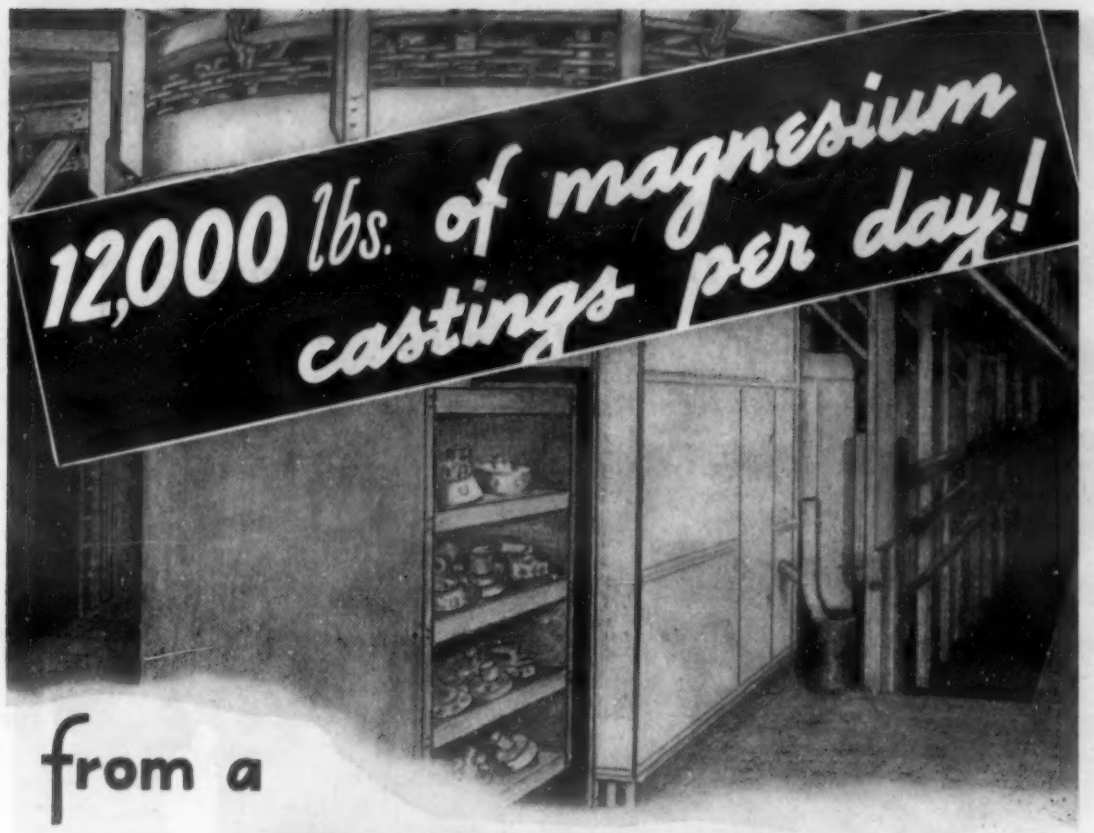
Make Your Dollars Fight —Buy More War Bonds

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

P. R. MALLORY & CO. Inc

MALLORY *Standardized Resistance Welding Electrodes*





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ROSS

AUTOMATIC

HEAT TREAT OVEN

Evenly graduated heating and uniform distribution under constant automatic control, plus a modern conveying arrangement make possible the remarkable performance record of the ROSS Heat Treat Oven—solution heat treating, air quenching and aging in one continuous operation. No labor. No handling.

12,000 pounds of magnesium castings per day is typical of records being made by other ROSS Ovens for the treatment of non-ferrous metals—continuous and stationary types.

Write for your copy of our Bulletin No. 130 that describes the various types of ROSS Ovens—their advanced design and operating advantages. It will be sent to you without obligation.

Among Users of ROSS Heat Treat and Aging Ovens are:

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Packard Motor Co.
Reynolds Metals Co.
Tube-Turns, Inc.
Wright Aeronautical
Corp.,
and many others.

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ROSS ENGINEERING OF CANADA LIMITED—DOMINION SQUARE BUILDING—MONTREAL

of the sheet; and (2) the slope of a transverse cross section of the punch.

These two effects are often opposed, so that if one causes compression, the other causes tension in the transverse direction. If the compressive effect predominates, a tendency to form longitudinal wrinkles will result.

It is hoped that the methods of stretch forming may be improved so that in some cases compressive forces causing wrinkling may be avoided, and in other cases enough support may be given to the sheet (for example, by rubber pads) to prevent wrinkles even though the compressive forces are present. Then the only limit to stretch forming will be the tearing of the sheet due to excessive elongation.

—R. B. Glassco & N. O. Myklestad. *Steel Processing*, Vol. 30, Mar, 1944, pp. 168-171; 177-178; Apr. 1944, pp. 222-224.

Milling with Negative Rake Angles

Condensed from "Mechanical Engineering"

The use of negative rake milling cutters tipped with sintered carbide has permitted cutting speeds appreciably higher than those formerly thought practical. This practice has been most developed on the Pacific Coast, where they now use a relatively large feed per tooth and a somewhat lower cutting speed than originally.

It is usually down milling, and a flywheel is used if possible. In many cases, the feed rate is limited only by the available power. The advantages are higher production, improved finish, and less distortion due to heat.

The negative rake gives a stronger tooth form. Although former tests showed the power required to remove a given amount of metal increased greatly as the conventional positive rake angle decreased, recent tests have shown that the specific power for negative rakes is high only when the speed is low.

As the cutting speed increases, the power required with negative rakes decreases steadily, and over a certain speed may approach that of tools with positive rake angles. If better cutting tool materials are developed, it is possible that the further increased speed may give negative rake tools the added advantage of lower power consumption.

A series of tests was made in a special machinability dynamometer. With a 10° negative rake, the cutting force decreased with increasing speed; with a 10° positive rake, the cutting force increased with increasing speed. This, for example, in machining 4340 steel at 210 Brinell with a sintered carbide tool, the cutting force was about equal at 730 ft. per min.

The point of approach of the force curves varies with conditions, and tends to be lower with larger feeds. These tests were made with single point tools, but similar results have been obtained with high-speed milling cutters on steel and aluminum.

Friction Decreased

These results are due to a decrease in

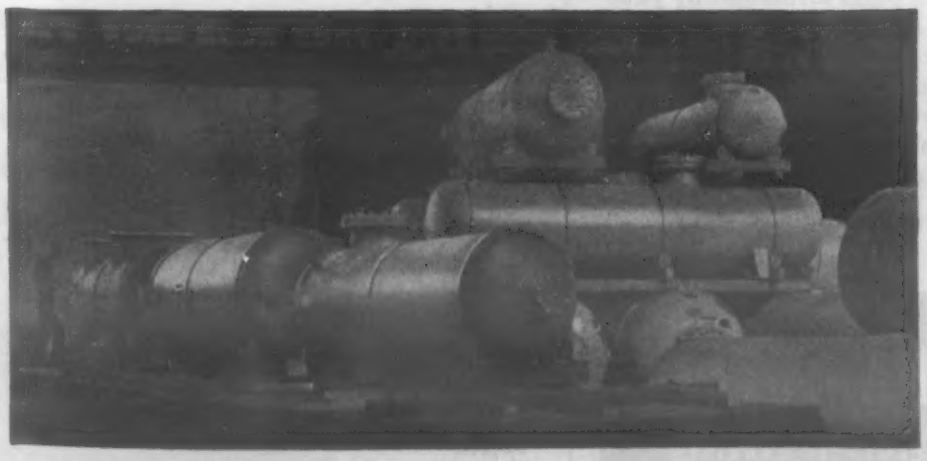
It has always been the policy of the Metal & Thermit Corporation to pay special attention to the development of electrodes for welding special steels. Murex Carbon Moly. 50, Molex and Type M, for example, are outstanding in their performance for welding carbon-molybdenum steel plate, castings, high pressure, high temperature piping and pressure vessels. Murex R.C. and C.F., for the repair and welding of air-hardening steel castings are among the electrodes developed to meet the needs of war production.

As the electrode requirements of fabricators change with the advent of industrial conversion, suitable Murex Electrodes will be available.

PROVIDING HEAT AND FRESH AIR FOR OUR COMBAT VESSELS, these heating units, produced by McQuay, Inc. of Minneapolis, must be rugged to withstand gunfire shock and near miss bomb concussion. To combine sturdy construction with light weight, welded construction using Murex Electrodes was adopted for the heater casings.

HUGE TURBINES FABRICATED WITH MUREX ELECTRODES by S. Morgan Smith Company, world's largest exclusive turbine builder. The illustration shows welding of a three-way branch inlet of a Vertical Impulse Turbine. Advantages of arc welding are: elimination of possible defects of complicated castings; less metal used; figuring of exact weights possible, thus enabling manufacturer to keep within estimates. Down-hand Murex Electrodes are used.

THIS 7½-TON STEEL CYLINDER on an 800-ton hydraulic press developed a crack 20 inches long and after preparation for welding 3 inches wide, and from 4½ to 6½ inches deep. Preheated 9 hours at about 700° F., this temperature was maintained during 17 hours of continuous welding with Murex Type F ¼ inch rods. The Detroit & Cincinnati Welding Company report that cylinder wall distortion was only about .0015" and that the flange moved only .004".



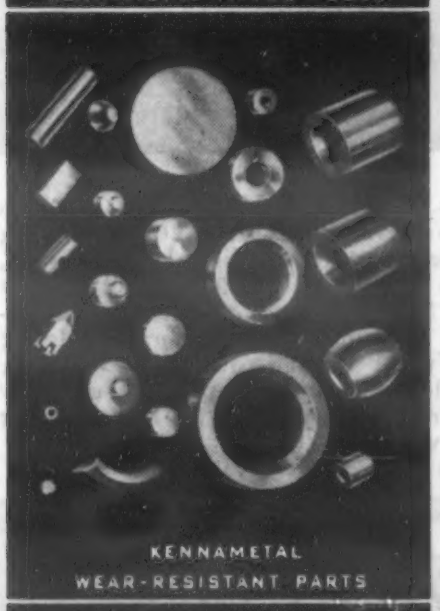
PRESSURE TANKS FOR HIGH OCTANE GAS, produced in quantity by The Bigelow Company of New Haven, Connecticut, are welded with low alloy Murex Electrodes to withstand pressures of from 100 to 600 pounds.

MUREX
ARC WELDING ELECTRODES
•
METAL & THERMIT CORPORATION
120 Broadway, New York 5, N. Y.
ALBANY · CHICAGO · PITTSBURGH
SOUTH SAN FRANCISCO · TORONTO
Specialists in welding for nearly forty years. Manufacturers of Murex Electrodes for arc welding, and of Thermit for repair and fabrication of heavy parts.

This unique piece of metal

KENNAMETAL-TIPPED TOOL - STYLE NO. 12

PIECES MACHINED WITH KENNAMETAL-TIPPED TOOLS



KENNAMETAL WEAR-RESISTANT PARTS

KENNAMETAL INSERTS ON TABLE GRINDER

... SOLVES MACHINING PROBLEMS ...

"Too tough to machine, too hard to work"—time and again these words by production men sounded the death knell of designers' specifications. That is, until the discovery of Kennametal, the unique cemented carbide composition whose amazing hardness immediately established it as a tool material that makes practically any metal easy to cut. Kennametal-tipped tools swept away traditional machining limitations—making practical the cutting, boring, and milling of materials up to 550 Brinell at speeds that multiply output, and substantially reduce production time and costs. This application of Kennametal is a tremendous aid to better machine design, since it permits the use of tough, hard, lighter-weight parts instead of cumbersome components that were incorporated primarily because of their "machinability." Write for our Catalog 43-C that describes Kennametal tools. Study it with your production men—learn how to use the most advanced metal-cutting technique to improve your designs.

... IMPROVES PRODUCT PERFORMANCE...

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the coefficient of friction and the force of friction of negative rake tools operating at high speeds. The reason is not completely clear, but it is partly due to a decrease in the shear strength as the result of an increase in temperature in a thin layer of the chip metal adjacent to the tool face. A study of chip flow phenomena tended to substantiate these results.

However, to get increased production, good finish and long cutter life with this method of milling, it is essential that great care be exercised in the preparation and maintenance of cutters. In many cases, variations in performance or poor performance with the new procedure are due to improper practice in cutter grinding.

The cutting edge must not be overheated. The grinding wheel should be rotated against the tooth being ground. Only very small amounts of carbide should be removed per pass (preferably under 0.0003 in. per pass for roughing and 0.0001 to 0.00015 in. per pass for finishing). Diamond impregnated wheels should be used (100 grit for roughing and 400 grit for finishing).

A pad soaked with kerosene or very light oil should bear against the wheel while grinding. However, sufficient carbide must be removed to eliminate the damaged portion of the tool. For this reason, it is best to change the cutters when the tool is only slightly worn. After grinding, the cutting edges should be inspected with a low power microscope.

A rigid workpiece mounting is necessary. Flywheels should be used to maintain a more uniform cutting speed. With properly designed and carefully ground cutters, it is possible to get excellent results with existing milling machines. The high cutting speeds now used permit in certain cases the use of considerably higher powers than have generally been provided on standard machines without overloading the cutting teeth.

The machine tool manufacturers are fully aware of the possibilities of this type of milling. Even better production can be expected in the future from machines specially designed for sintered carbides.

—H. Ernst. *Mech. Engineering*, Vol. 66, May 1944, pp. 295-299.

Electronic Drying for Paint

Condensed from "Industrial Finishing"

Heat can be produced electrically to dry method, the metal object, the finish on which is to be baked, is passed through a coil of wire carrying a high frequency electric current. The high-frequency current in the wire induces currents in the object.

The induced currents heat the object, at a rate and to a temperature depending on the amount of power applied and on the electrical and thermal properties of

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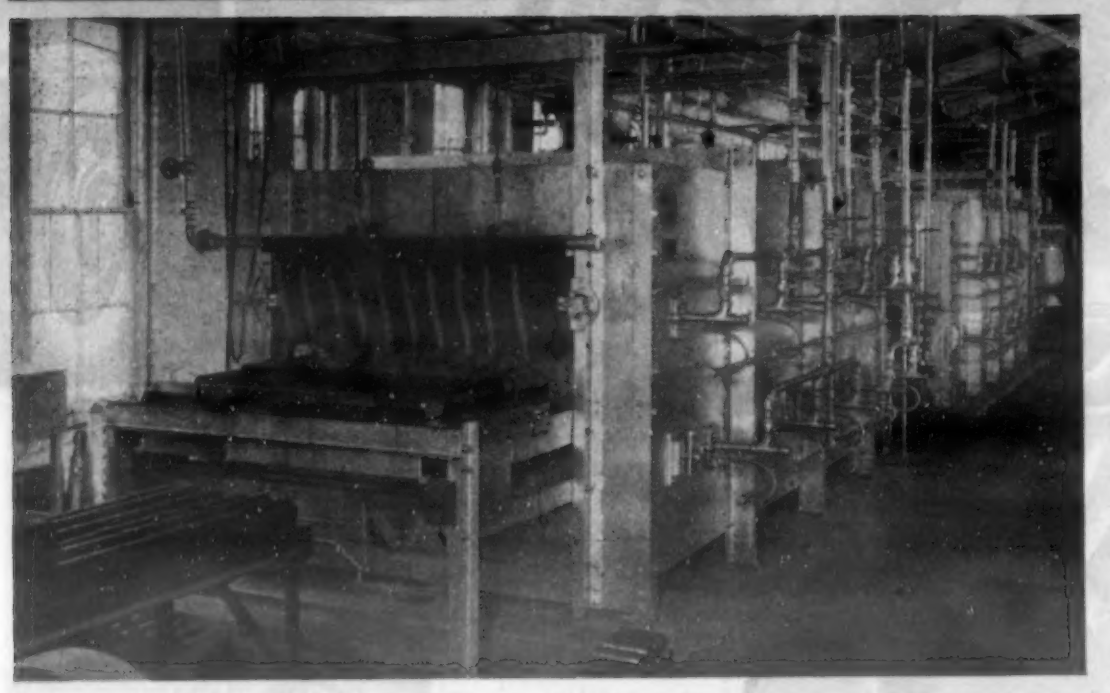

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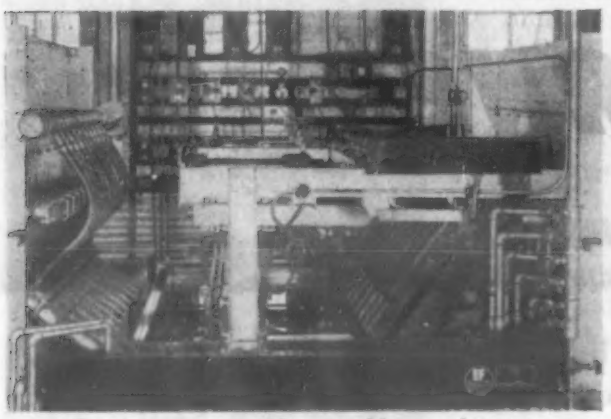

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the object. The paint coating is thus baked "from the inside out".

High-frequency currents tend to travel on the surface of a conductor. Thus, a current with a frequency of 400,000 cycles per sec. in iron or steel flows in a surface layer only 0.001 in. thick. It is therefore possible to heat only the surface of an article.

Some applications of this principle to the drying of paint coatings have been made, including the drying of paint on automobile bodies and on metal radio tubes.

As a result of some experimental work on this method of baking paint finishes, the following conclusions were reached: (1) The success of the method depends largely on the type of paint used. The drying of some paints was greatly accelerated, while other paints tended to blister.

(2) Iron and steel parts of thin cross-section can be most economically heated by this method. Objects of solid cross-section and of metals, such as copper or aluminum, require a great deal of energy in order that a high surface temperature be maintained for an extended period of time.

(3) In the experiments, the drying time of one paint was reduced from 30 min. to 5 min. It is reported that some paints could be dried in 15 sec.

The process has possibilities in certain applications, and research by paint manufacturers to develop paints suited to this method of drying was suggested.

—*Ind. Finishing*, Vol. 20, Apr. 1944, pp. 36, 38, 40, 42.

"Soft Skin" on Finished Surfaces

Condensed from "The Engineers' Digest"

It is often claimed by makers of measuring instruments that measuring surfaces have to be lapped, not only to obtain high accuracy, but also to remove the soft layer produced by the grinding process, thus increasing the life of the surface. So far it has not been possible to prove or disprove this statement, which apparently is based on practical experience.

Whether or not a soft skin has to be removed by lapping is of great importance from a production standpoint, since the lapping process requires additional time and highly skilled labor.

A method was developed by which it is possible to examine test specimens metallographically during various stages of grinding and lapping, and by the use of this method an effort was made to detect the "soft skin".

The test method is as follows: An optically flat surface is produced on each of two test specimens. [A new method, not described was used for producing the optically flat surfaces. The method is stated to employ cutting, not grinding.] When the surfaces so prepared are lightly polished and etched, no rounding at the edges worth mentioning can be observed at the highest mangnifications.

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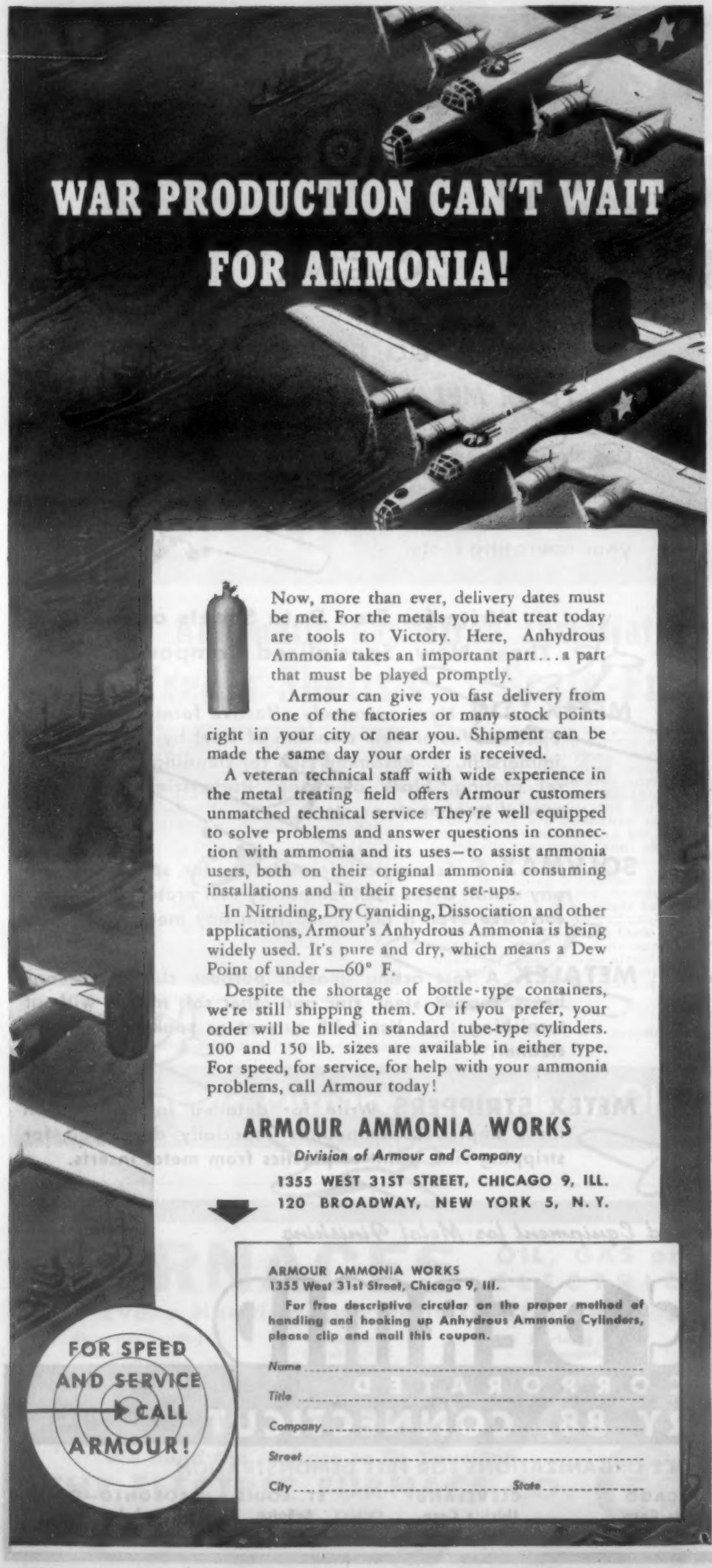
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The flat test surfaces were bolted together firmly face to face after polishing and etching. The edges were then ground and lapped, and the cross-section of the surfaces exposed at the lapped edges was examined photomicrographically, and by microhardness measurement (Vickers and scratch). As a result of difficulties involved in making and interpreting the hardness measurements, a soft skin could not be detected by these measurements.

According to Junger, a soft skin is blackened when etched for a short time with a 3% alcoholic nitric acid solution. Several ground surfaces showed a slight blackening when treated in this way.

The blackened layer was removed with the finest emery paper, and the procedure repeated until no blackening took place. The thickness of soft skin found in this way was 1 to 2 microns (0.00004-8 in.).

Examination of the photomicrographs of specimens ground under normal conditions show that the structure is normal practically to the edge of the specimen. Any structural change, if it does exist, cannot extend into the metal through a thickness of more than 2 to 3 microns at the most. However, a Poldi Stabil steel that was ground with a carbide disk of the Skoda-Sawin wear testing machine shows a change in structure through 10 microns (0.0004 in.).

It is admitted that the results of this work do not settle the question of the "soft skin" and its properties, and it is concluded that the only possible means of detecting structural changes more definitely is by electron interference.

It is shown that the soft skin must exist in a very small zone, and therefore today most measuring surfaces should not be lapped. Only gages with very small tolerances where great accuracy is required should be lapped.

—I. P. Leinweber. *Werkstattstech., Der Betrieb*, Vol. 37/22, June 1943, pp. 241-243; abstracted in *Engineers' Digest (British)*, Vol. 5, Mar. 1944, pp. 65-67.

Weld-Cracking

Condensed from
"Zeitschrift für Ver. deut. Ing."

In the fusion welding of steels, three types of cracking phenomena can be observed differing from one another by their nature and cause. Weld cracking occurs in welding thin sheets and thin-walled pipes of high-strength steels, and is therefore of importance in light structures. It has not been observed so far in soft, unalloyed steel with a carbon content up to 0.2% and a tensile strength up to about 42 kg/per sq. mm. (60,000 p.s.i.)

In the weld-cracking material, hot cracks occur under the influence of welding strains next to the gas-welded seams that run along the grain boundaries, *i.e.*, intercrystallinely. The tendency to weld-cracking increases in general with decreasing thickness of material, with increasing mechanical strength of material, and increasing magnitude of welding strains.

The hardness of the weld has, however, no relation to the tendency to cracking. Weld-cracking does not occur in electric arc welding because of the different heat action of the arc and because thicker material is used.

Welding sensitivity exists if steels that tend to strong hardening next to the seam due to their content of alloying elements are welded as very thick pieces with the arc. Cracks form, even with correct design and welding operation, next to or even in the welded seam. The cracks are intercrystalline and run parallel or perpendicular to the seam.

During or after cooling, the hardened zone cracks. For thicknesses of 6 to 20 mm. (¼ in. to ¾ in.) of the material, the welding sensitivity is not so important, but for thicker materials, a more critical condition exists because of the formation of multiaxial strains. Restriction in alloying elements, proper melting and heat treatment influence and can alleviate the welding sensitivity.

Welded seam cracking is defined as the occurrence in welded seams, especially in fillet welds, of longitudinal or transverse cracks during cooling which, under certain conditions, continue into the base material. This type of cracking occurs almost only in arc welding of steels of higher mechanical strength with thickly coated electrodes.

It has been found that welded seam cracking occurs frequently if the material contains over 0.06% P, or over 0.05% S. The tests developed by German plants for detecting the three types of cracking are briefly described.

—K. L. Zeyen. *Luftfahrtforsch*, Vol. 20, No. 89, 1943, pp. 231-241; abstracted in *Z. Ver. deut. Ing.*, Vol. 87, Dec. 25, 1943, pp. 802.

Sulphurized Cutting Oils

Condensed from "Steel"

Sulphur, when added correctly to mineral oils or mineral-lard oils, increases cooling and lubricating ability; helps to prevent welding of chip to tool; permits more rapid cutting; and gives smoother surface finish on steel, because of added film strength and easier penetration to small crevices.

Sulphurized cutting oils are not a cure-all for machining difficulties. For example, highly sulphurized oils are unsuitable for machining brass or non-ferrous alloys, because the sulphur causes the surfaces of these metals to turn black.

Where visibility is desirable, reduced viscosity of oil is important. Oils of this nature are especially adapted to the machining, of low-, medium- and high-carbon steels and the several types of alloy steels used for precision and heavy-duty machinery. The corrosiveness of a sulphur cutting oil can be reduced by heating the oil sufficiently to cause the free sulphur to react with the mineral oil to form non-corrosive products.

The cutting speed for a given life to tool decreases almost directly as the hardness of steel increases. Cutting speed influences

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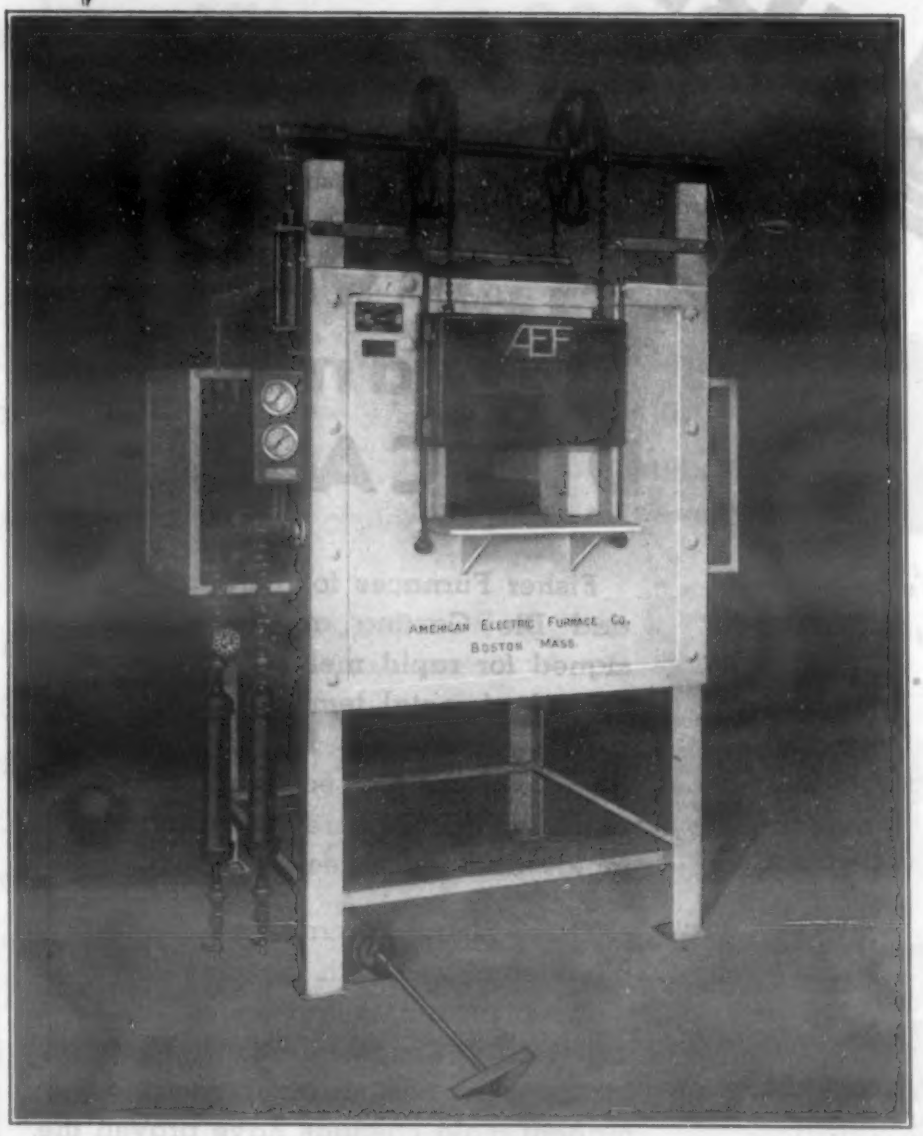

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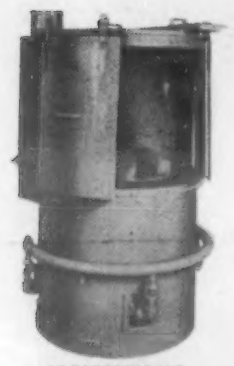

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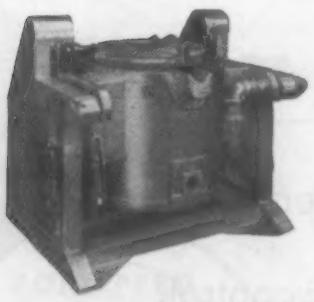

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greatly the quality of machined surfaces, independently of other factors. In cutting a steel at low speed, the finish is usually poor. Under these conditions a high rake, a light feed, and a cutting oil containing sulphur or chlorine should be used.

As the cutting speed increases, the finish becomes better. For each structure a cutting speed is obtained at which the built-up edge disappears. The speed at which this superior finish is obtained varies not only with the type of steel cut, but also with the structure of the steel. This speed is lowest for the hardest metals, and highest for the softest metals.

Under normal cutting, cooling is believed to be the primary function of the cutting fluid, so that aqueous solutions or emulsions are more desirable. These should be applied at relatively low temperature (about 80 to 110 F.) in large quantities and at high velocity.

In the study of sulphurized cutting oils, both laboratory and field research were conducted. Cutting of pipe threads afforded an excellent means of evaluating oils.

The "lead abrasion" method is a dependable method for testing the smoothness of cut surfaces. A heavy-duty turret lathe is used to make a cut on the end of a piece of lap-welded or seamless steel pipe. The roughness of the cut surface is measured in terms of inches of lead worn off when a pencil-lead abrasion apparatus is passed over a definite linear distance of the surface. Pressure on the pencil lead is kept essentially constant regardless of the wear on the lead.

Sulphur cannot be added at random to a mineral oil. The manner of compounding and the nature of the materials to be compounded are the salient factors.

--A. F. Brewer. *Steel*, Vol. 114, May 1, 1944, pp. 104-105, 141-142, 144, 146, 148.

Glass Processing Steel Products

Condensed from "Wire and Wire Products"

A process has been developed whereby in passing cleaned wire through a bath of molten glass, the coating deposited on the surface of the steel prevents much oxidation of the steel, and what little does take place is removed when the glass is taken off. The glass can be applied to high carbon, stainless and other grades of steel.

So far the process has been applied to wire and narrow stainless steel strip, but it can probably be made to apply to all grades of strip, sheet and bar steel.

It can be applied to wire rods as the hot rod exits from the finishing pass, or just as it enters the reel guide, where spray guns are located to spray molten glass (hot snow) on all surfaces. The glass coating will insulate the rod against further oxidation through its cooling temperatures. As the rod cools below this temperature the coating will separate from exposed sections, removing oxides.

Though the strands will adhere in coiling, these strands automatically separate at the wire drawing machine, taking off

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At the Glenn L. Martin-Nebraska Company in Omaha, aluminum alloys 17S and 24S are increased in strength from 26,000 to 68,000 pounds per square inch.

In this process, parts to be heat treated are wired into charging racks and then immersed in a sodium nitrate bath at 920° F. After treatment, the parts are quickly quenched in cold, circulating water and finally rinsed to remove remaining salt.

The welded treating tank is 15 feet long, 2½ feet wide and 4½ feet deep. Constructed of Lukens "L" Nickel-clad steel, it holds 1000 gallons of the molten salt.

Although this salt is highly corrosive, carbon-free "L" Nickel provides excellent resistance to corrosion.

INCO Technical Service will be glad to furnish detailed information regarding this process, or to assist you with individual heat-treating problems. The use of "L" Nickel, Inconel and other nickel alloys is today restricted to approved applications . . . but our technicians are *always* at your service.

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This is an important feature where it is desirable to prevent contact of the gas with the lubricant, or where external leakage of the gas might be dangerous. Another advantage is that the packing and shafts are subject to less wear and friction since the stuffing box gland need not be drawn so tight.

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the oxides and leaving a clean surface. The coating is collected and returned to the blast furnace. The glass can be used over at least three times, costing $18 per ton, which coats 100 tons of steel.

When the rod arrives at the drawing department it is placed on a reel, passed over vertical and horizontal rolls or bars to remove coating and oxides, passed through a container in which is a carrier for drawing lubricants, then drawn.

If the wire is to be galvanized, it is passed through molten glass and heated to about 2000 F. At the exit, die plates are located with an opening 1/16 in. in diam. larger than the wire to be processed to give a thin uniform coating of glass.

It is then passed over a roll, and as it cools the glass separates with the oxides. It is then passed through a flux and into the conventional zinc bath.

Lead coated stainless steel wire is treated in much the same manner. When properly cooled, the lead peels off with the glass. The coating containing the lead is returned to the glass container, a reducing agent added, the lead being recovered in metallic form.

As to strip steel, the same method is used except that the die hole must correspond to the width and diameter of the strip (instead of being slightly larger). The glass separates violently, due to flat surfaces, and care must be taken to protect the eyes of the operator.

The processing speeds are the same as for the conventional methods. Flint glass is used for stainless, alloy steel, and low carbon steel containing no silicon. Soda lime or white bottle glass are used for high carbon and high silicon steel.

The glass is melted in a graphite crucible in a special furnace, the crucible being furnished by the Vesuvius Crucible Co., Swissvale, Pa., and the furnace by Monarch Engineering & Mfg. Co., Baltimore.

—John J. Caugherty. *Wire & Wire Prod.* Vol. 19, May 1944, pp. 299-303.

Die Casting Copper-Zinc Base Alloys

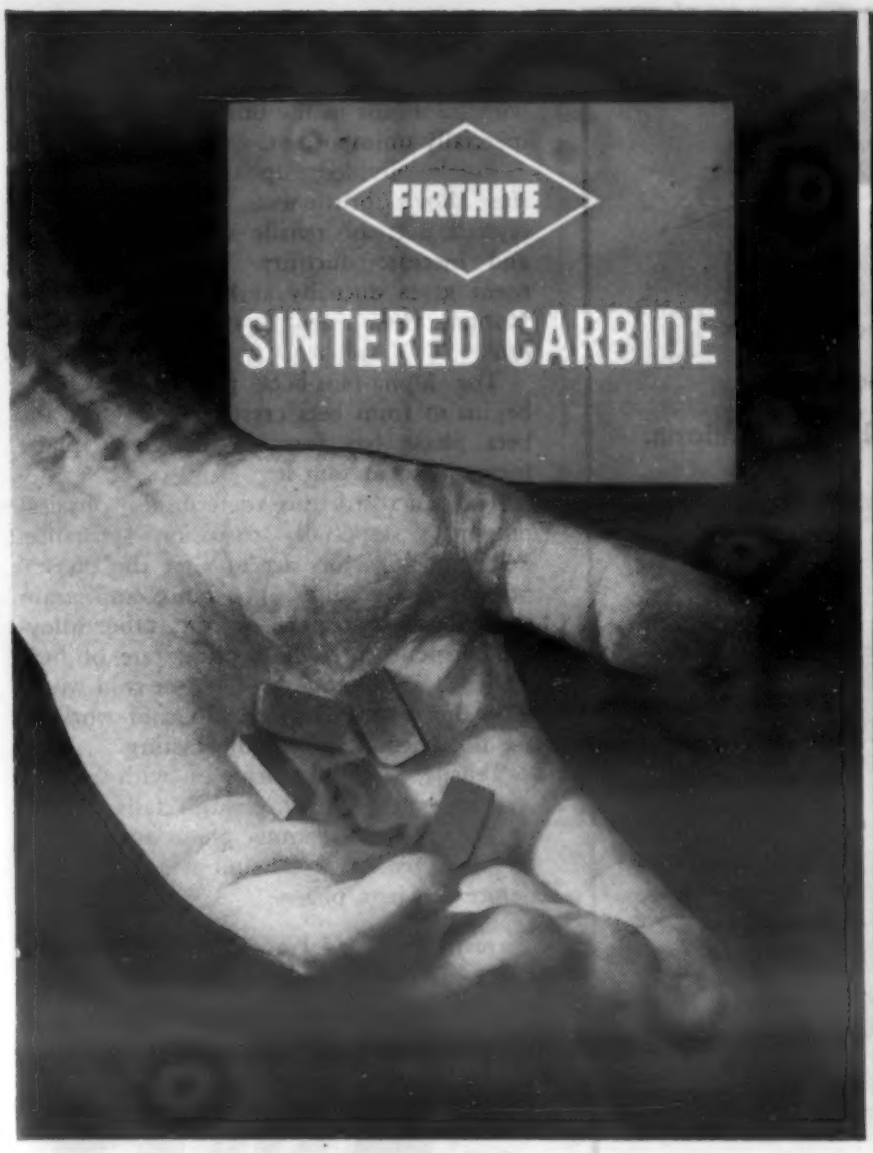
Condensed from "Western Metals"

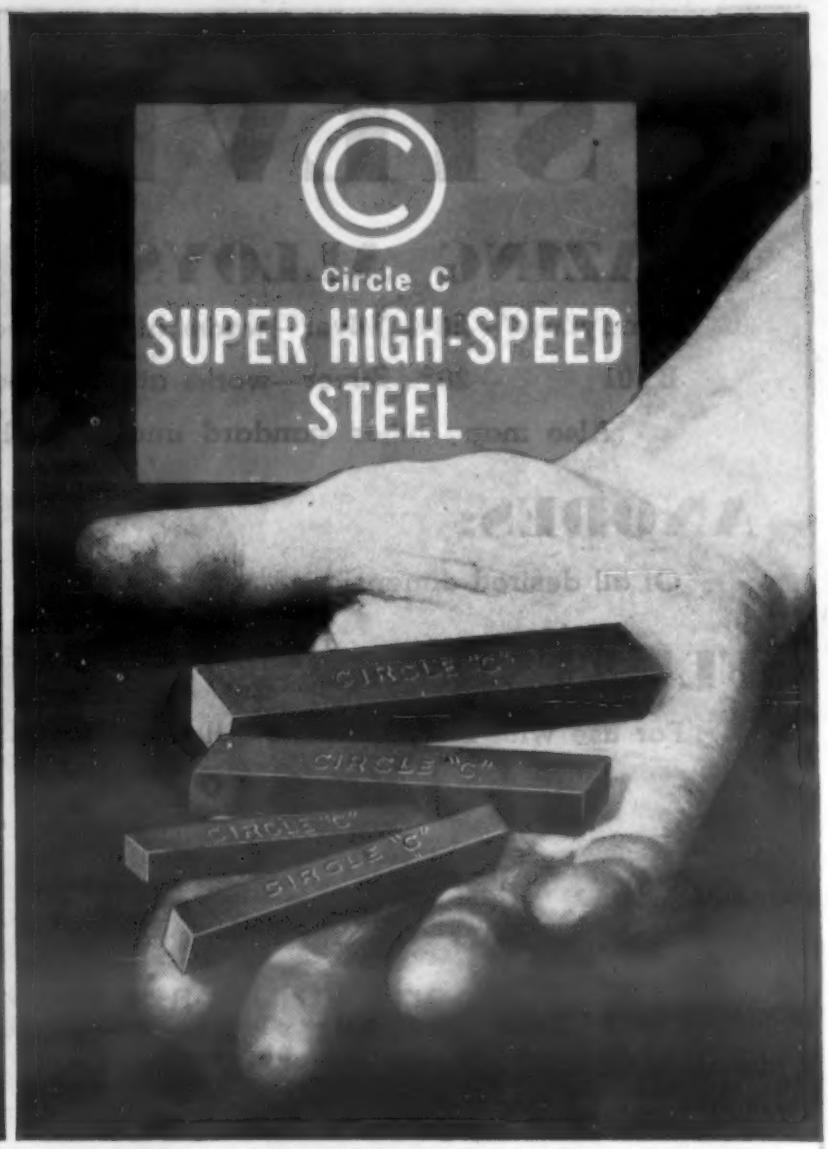
Specifications governing the die casting of copper-base alloys are few. The SAE and ASTM specifications for manganese bronze are the only ones of any importance.

The absence of government specifications governing copper-base alloy die casting is partly because so many die casting companies have their own commercially patented alloys for die casting, and any general specification would be without meaning. Starting at the copper-rich side of the phase diagram and moving toward the zinc-rich side, the new phases appear one after the other.

Each phase is a solid solution that is "homogeneous, physically distinct and mechanically inseparable". Alpha disappears at about 46.5% Zn, but phases do not disappear abruptly but merge for a time.

Pure copper has a face-centered cubic lattice crystal structure, which is retained





THERE ARE PLACES FOR BOTH . . .

Firth-Sterling, long specialists in making steels for shop tooling, early recognized the possibilities of carbides as a means of extending the improvement in shop practice brought about by the super high-speed steel—CIRCLE C. **But, there is a place for both . . .**

Where the highest speeds are obtainable or materials are hardest, FIRTHITE is the "last word" in a cutting material. It is used at speeds up to ten times those possible with high-speed steels. Where speeds above average are permissible or materials are "on the hard side," CIRCLE C will cut *at least* 25% faster than ordinary grades of high-speed steel. Send for descriptive literature on these remarkable materials.

For instance:

FIRTHITE *removes* 730 pounds of gray-iron casting metal per hour instead of 180 pounds;

drills a gun barrel in 23 minutes instead of 1 hour;

enables milling-cutters to run at 1,000 feet per minute instead of 100 feet with previous materials.

For instance:

CIRCLE C *machines* hard die blocks in 28 hours instead of 42 hours . . . doubling production between grinds — versus regular high-speed steel;

turns two to ten times more pieces of heat-treated alloy steel between grinds than other high-speed steels.

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Write for Bulletin WP-22

CULLEN-FRIESTEDT CO., 1314 S. Kilbourn Ave., Chicago 23, U.S.A.

until 29% Zn is added. The beta-phase has a body-centered cubic structure; the gamma phase has a complicated cubic structure with 52 atoms in the unit cell, and is commercially unimportant.

Finely divided alpha crystals increase the alloy's brittleness, but larger alpha crystals decrease tensile strength somewhat and increase ductility. The beta constituent gives ductility at high temperatures. Normal alpha, cast, has polyhedral structure.

The alpha-plus-beta phase on cooling begins to form beta crystals first. Once the beta phase has formed, the alpha phase forms in turn from it.

The microstructure determines physical properties, especially corrosion resistance. Four major factors act to alter the phases' presence, crystalline appearance and grain size: Ratio of copper to zinc, other alloying elements present, cooling rate of heat treatment, and amount of hot or cold working. But heat treatment and cold working are not encountered in die casting.

Tensile strength increases with an increasing zinc content, though falls off abruptly when the gamma phase arrives. Elongation reaches a maximum and falls off before the beta phase.

Microstructure and Properties

Hardness is constant until 38% Zn is reached, increasing rapidly with the beta phase and thereafter. Alpha has greater resistance to shock than beta. Alloys with alpha phase are especially suited to cold working.

Beta phase brasses may be easily forged, hot rolled or extruded, but have inferior fatigue resistance. Beta has higher ductility at high temperatures than alpha. Die casting tends to produce a much smaller grain size than sand or chill casting. Hardness increases with decreasing grain size.

Often other metals than copper and zinc are used in the copper-zinc base alloys to save copper or zinc and give certain properties. Aluminum acts like zinc, 1% having an effect equivalent to 6% Zn. It causes the beta phase to appear at low zinc contents.

Iron acts like zinc, causing the beta phase to appear at higher than normal zinc concentrations. Manganese acts like copper when added. Lead is insoluble in either copper or zinc, and forms small spherical globes. It is soluble in beta brass up to 0.9%.

At one time tin was added to brasses by foundrymen, but today it is being supplanted by silicon, which is cheaper and easier to obtain. Silicon increases corrosion resistance.

• Nickel, at least 10%, increases ductility and acts like copper in causing the beta phase to appear at higher zinc contents. Phosphorus in 70-30 alloy acts as a grain refiner. Beryllium hardens the alpha phase of 57-72% Cu alloys, increases tensile strength, and sometimes refines grain. Bismuth causes brittleness, even in small amounts.

Brass die castings are seldom heat treated because as yet no successful method for producing porosity-free castings has been developed.

—James L. Erickson, *Western Metals*, Vol. 2, Mar. 1944, pp. 7-10, 12-13, 15-16; Apr. 1944, pp. 8-12, 15-17.

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For AC, and either polarity on DC. • Tensile strength, 65,000-70,000 P.S.I. • Yield, 55,000-60,000 P.S.I. • Ductility, (2") — 18% to 25%. • Available in all sizes — 14" and 18" lengths.

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Balancing Rotating Parts

Condensed from "Modern Machine Shop"

Unbalanced rotating parts will lead to undesired vibration, noise and a shortened life. Speed has a direct bearing on the necessary degree of balance, for the centrifugal force varies as the square of the speed.

Formerly static balancing equipment was adequate, and even now it is used in some cases. The simplest set-up is four discs mounted in pairs with each pair overlapped and so aligned that a shaft laid across the edges of the discs will nest and be properly supported. If the workpiece is out of balance, it will revolve until the heavy part is at the lowest position. If the piece remains without motion at any position to which it may be revolved, it is in static balance.

Ball bearings are always used to decrease friction. If the revolving plate and axis upon which it revolves are absolutely concentric, it is possible to balance parts to ⅛ oz. in.

A workpiece with a short axis is better mounted on a vertical stud for balancing. The machine has a universal spirit level that instantly indicates the angular location of the point of unbalance and a special weighing mechanism that shows the amount of metal that must be removed. With this machine, it is possible to balance to within ¼ oz. in.

Another type is built on the principle of the plumb line in which a suspended weight comes to rest with the heaviest point lowest. The unbalance is transmitted by an aluminum beam to a universal spirit level, which indicates the position and amount of unbalance. Many of these machines are provided with their own drills for correcting the unbalance.

Airplane propellers may be balanced in a machine with two level ways on which an arbor may roll. The propeller is mounted on the arbor and balance weights provided at one end of the arbor. The weights can be moved to compensate for the unbalance; as they are graduated in inch pounds, it is possible to show the amount to be removed directly.

Inadequate for High Speeds

If high speeds are involved in service, static balancing is inadequate as small differences are magnified tremendously at high speeds. There are portable dynamic balancers and vibrometers that can be used in the field without removing the part from its machine. The readings give the weights that must be applied to correct the unbalance.

Some machines provide for both dynamic and static balancing. In some cases, especially with long crankshafts, more than two supports are required for balancing. The unbalanced crankshaft is placed on the rolls of a vibrating frame and connected to the drive head of the machine through a flexible coupling.

The angular position and amount of unbalance are indicated by an electric spark. A special weight holder may be swung into the plane of unbalance and the weights adjusted to bring it into balance. The shaft is then turned end for end and the process repeated.

In one supersensitive dynamic balancing machine, a neon light is used to discover and indicate the planes of unbalance. The shaft is supported on two self-aligning ball bearings. Its particular advantage is that the unbalance in one plane can be "locked out" while the true reading is obtained in another plane. The amount of correction can be read on dials sensitive to 0.2 oz. in.

The radio principle of amplification is used in another dynamic balancing equipment, so the unbalance is deliberately multiplied for measurement. Vibrations of only 25 millionths of an in. can be located and measured with this equipment.

It should be remembered that a part statically balanced may not be balanced if it is rotating, and that a part dynamically balanced is balanced only for operation at speeds up to the speed used in balancing.

—J. E. Hyler. *Modern Machine Shop*, Vol. 16, May 1944, pp. 160-162, 164, 166, 168, 170, 172, 174, 176, 178, 180, 182, 184, 186, 188, 190, 192.

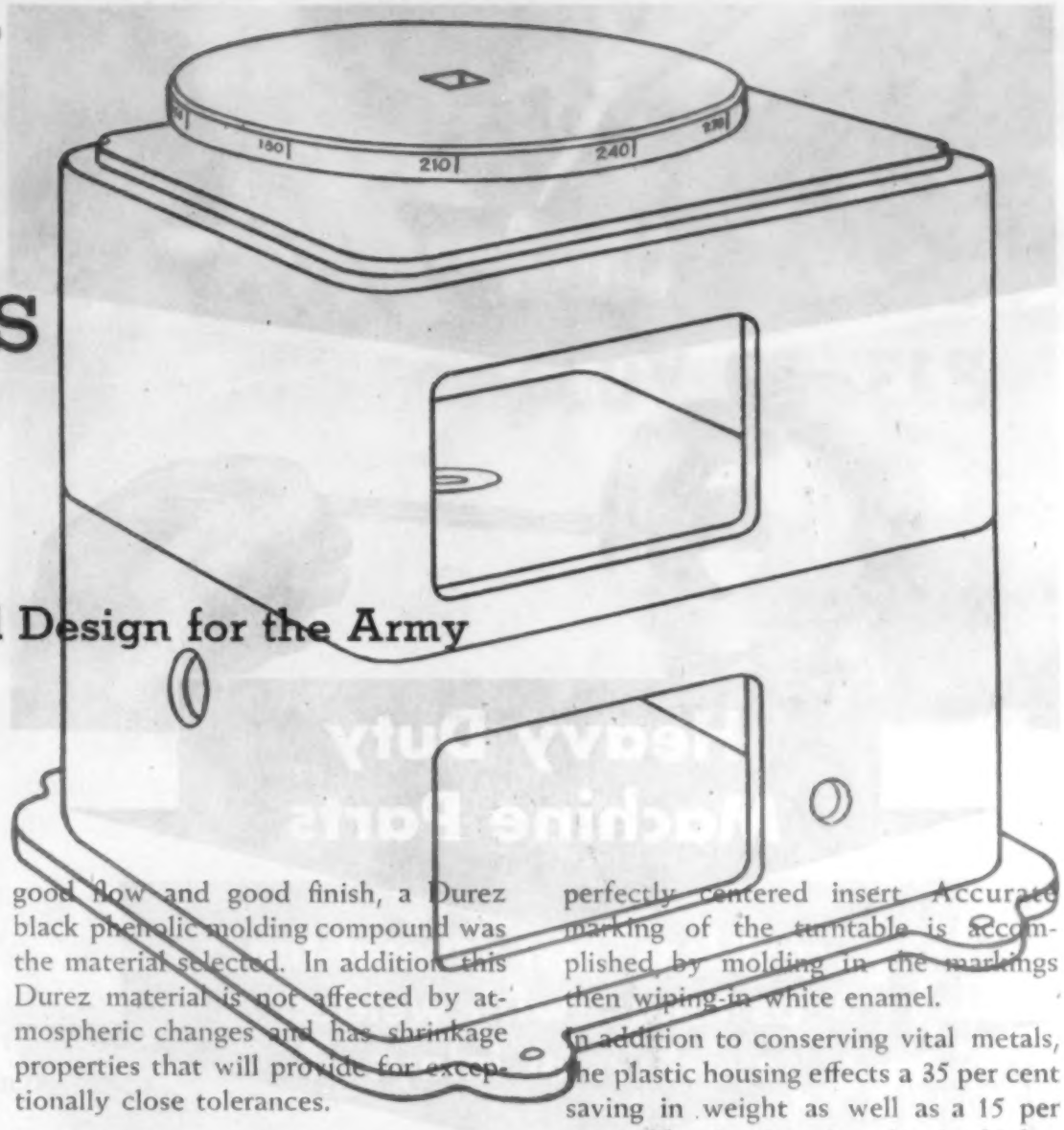
Porous-Chromium-Plated Rings

Condensed from "SAE Journal"

Specimens of standard plain gray-iron piston-rings, porous-chromium-plated to a thickness of 0.005 in., were heat treated at various temperatures from 100 to 1200 F. The specimens were held at these temperatures for one hr., as previous experiments indicated that the greater part of the change in hardness occurred within this time.

DESIGN DATA ON PLASTICS

VII. An Ingenious Mold Design for the Army



Of interest to designers and engineers is the cooperative spirit and ingenuity of American manufacturers in making every effort to win the war. An excellent example is the production of the aircraft instrument tester for the Army Air Corps. The machine replaces one made wholly of metal and designed many years ago by Army aeronautical engineers for field testing various aircraft instruments such as compasses and bank and turn indicators.

A redesign of the housing and turntable, to permit the use of a plastic instead of vital metals, involved three major problems. These were mold design for the housing, surface tolerance on the turntable and marking the turntable.

Because of its excellent dimensional stability, giving a very rigid set-up, good flow and good finish, a Durez black phenolic molding compound was the material selected. In addition this Durez material is not affected by atmospheric changes and has shrinkage properties that will provide for exceptionally close tolerances.

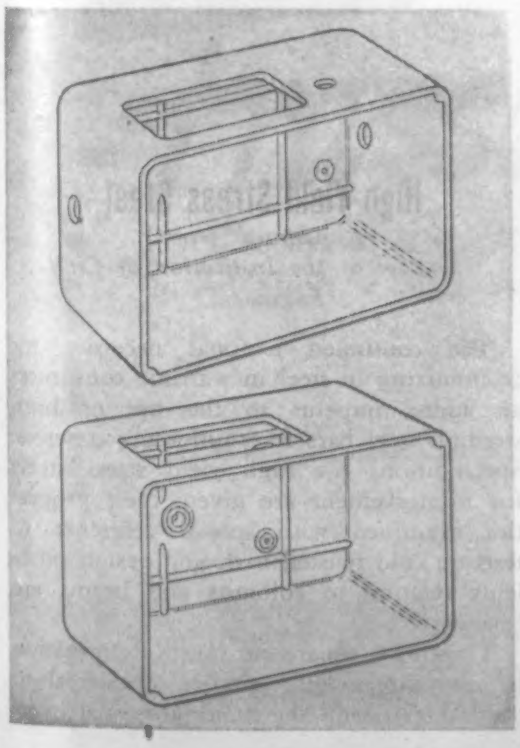
The housing consists of two molds, one for the base plate only, and one for the two halves. The mold for the main body of the housing is an ingenious design since the two halves are duplicates only in overall dimensions. Inserts, guide holes, etc., are different in the top half from those required for the bottom half. By a series of plugs and insert guides it was made practical to mold a quantity of one section, make a temporary mold change, and mold a similar quantity of the other section. By this arrangement a considerable saving in mold cost was effected.

Close tolerances are required for assembly of the housing, for alignment of the interior mechanism and to assure a level surface on the turntable and a perfectly centered insert. Accurate marking of the turntable is accomplished by molding in the markings then wiping in white enamel.

In addition to conserving vital metals, the plastic housing effects a 35 per cent saving in weight as well as a 15 per cent reduction in price, despite higher labor costs.

These Durez plastic-housed instrument testers are giving excellent performance in hottest Africa, the cold of Alaska, in the dryness of the desert and the monsoons of the Pacific. They have been double-checked for accuracy and are functioning to within one-half second in 1080° — three full turns of the table.

Efficient production of this plastic housing is the result of cooperative effort on the part of the manufacturer, molders and material producer. Such teamwork may help solve your design and engineering problems. We offer the facilities and research of our technical staff in determining the "Plastics That Fit The Job". Durez Plastics & Chemicals Inc., 97 Walck Road, N. Tonawanda, N.Y.



DUREZ

PHENOLIC MOLDING COMPOUNDS AND RESINS

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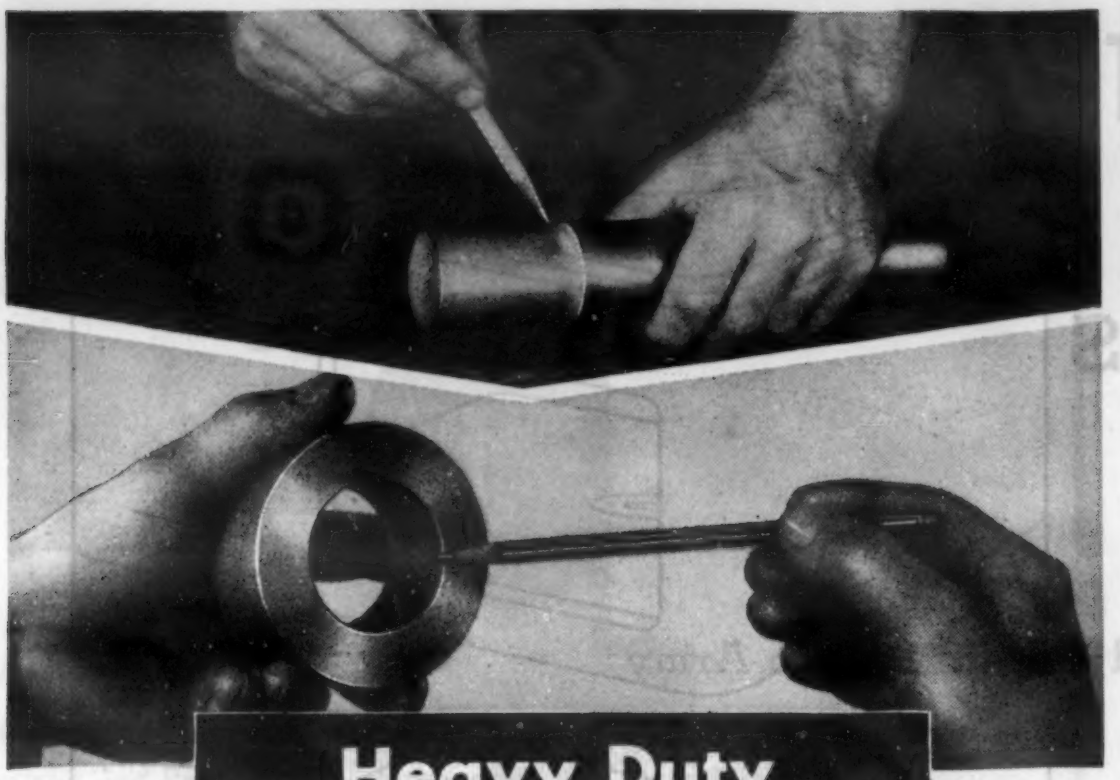

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While blueprinting your post-war products, consider the many advantages Ampco Metal has to offer you in increased sales appeal through greater dependability and durability — at considerable savings in cost.

Ampco-Trode coated aluminum bronze electrodes deposit weld metal comparable in strength, ductility, and bearing qualities with the various grades of cast Ampco Metal. This deposit can be applied to cheaper base metals to build up surfaces that resist wear, shock, and corrosion. Any grade of Ampco-Trode —selected for your required physical properties — can be welded to almost all metals and their alloys.

Illustrated above, are bearing surfaces that have been overlaid with Ampco-Trode to increase wear-resistance. This same principle can be applied to many machine tool parts where the problem of friction must be solved at low cost.

This modern method has a place in the production of your product! A letter or postcard will make available the services of a nearby Ampco field engineer — who will gladly explain in detail how Ampco-Trode can help you. Write today.

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W-4

The porosity was removed from the face of the ring, leaving the hard chromium highly polished, for hardness measurements. The Tukon tester with a 100-gm. load was used to determine the Knoop hardness numbers.

Results indicated that the decrease in hardness is gradual up to 500 F., with a sudden drop occurring between 500 and 600 F. The hardness then appears to remain at this new value up to 700 F., followed by a second sudden drop in hardness, ending at 900 F. The drop from 900 to 1200 F. is gradual, ending with a total hardness change of 400 Knoop hardness numbers.

To study the effect of time, tests were run on plated specimens held at 700 F. for more than 80 hr. Results showed that 90% of the drop in hardness occurred within the first hr., and no further changes took place after 5 hr. at this temperature. No explanation can be offered at this time why the two changes occur.

There have been occasions when a drop of 300 points in Knoop hardness numbers of the chromium surface was observed after a few hr. of operation, on rings installed in engines using superheated steam. Apparently the rings had operated at a very high temperature.

The effect of aircraft-engine operation on chromium-plated rings was investigated in the field. In an aircraft engine, only the top ring of each piston is chromium plated, and the remaining compression and oil rings are plain gray iron. Information was obtained from different parts of the country and for different types of engines. Some engines used plain cast-iron rings in the top groove.

The measurements show that cylinder wear is reduced greatly by use of one porous-chromium-plated ring in the top groove. Porous-chromium-plated rings show little wear under abnormal dust conditions, and their apparent life is exceptionally good. The chromium plate did not soften to any great degree. This indicated that apparently no unusually high temperatures had been reached in these engines.

—Tracy C. Jarrett. *SAE Journal*. Vol. 52, May 1944, Trans. pp. 222-224.

High-Yield Stress Steel

Condensed from "Journal of the Institution of Civil Engineers"

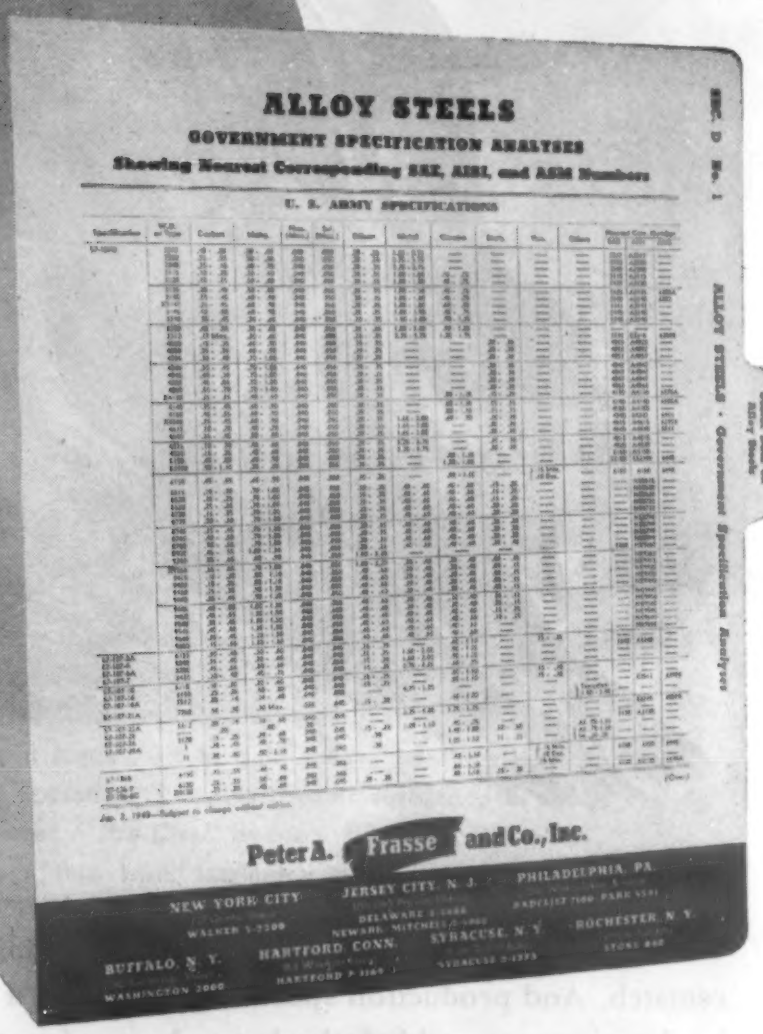
The continued national necessity for economizing in steel in wartime constitutes an added impetus to the use of high strength steel bars for reinforcing concrete. Specifications for high yield stress steels for reinforcement are given, their properties examined with special reference to tests on cold twisted bars, and design problems relating to columns and beams are considered.

Twisting a square bar causes deformation in planes originally parallel or normal to the bar axis, and the major torsional over-

(*Continued on page* 172)

New GOVERNMENT "SPECS" FOR ALLOY STEELS

Revised Frasse Data Chart Now Available



INCORPORATING all recent corrections and additions, this new Frasse Data Chart enables you to identify latest Government "specs" for alloy steels at a glance.

It shows the chemical analysis requirements for each Army, Navy, and Federal specification, together with its nearest commercial equivalent in SAE, AISI, and AMS numbers. Government "specs" for NE steels are included

The chart is handy file size, printed on tough stock, and suitable for wall or desk use. If you're working to Government "specs", you'll find it invaluable. Just send in the coupon—a copy will be sent to you by return mail.

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11

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TOOL DESIGNING . . . PRODUCTION PROCESSING

strain in transverse planes is augmented by a small direct stress overstrain.

Within limits, the greater the degree of cold working (measured by the number of twists), the higher are the yield and ultimate stresses and the less is the ductility, as shown by the characteristic stress-strain curves for twisted square bars.

There is for any given mild steel bar a certain number of twists that gives a specified elongation, another that gives a specified yield stress, and a third that gives a specified ultimate stress; the properties of the original bar determine the magnitude of these numbers.

A specified number of twists is, however, essential to ensure that cold working does not reduce the margin between initial failure and collapse by bringing the yield stress too close to the ultimate stress, and likewise a minimum number of twists is necessary to warrant the bar being termed "twisted". An acceptable number of twists for square bars is a pitch of one complete twist on a length of 8 to 14 times the thickness.

At normal temperatures the stabilizing effect of cold working lasts indefinitely and prolonged heating up to 1300 F. has little effect, although subjection for an hour or so to a temperature of 1600 F. entirely removes the effect of cold working.

The behavior of high yield stress steel in concrete is also briefly considered, and the working stresses for column and beam reinforcement dealt with as well as the economical aspects of using high yield stress steel for such work.

—C. E. Reynolds, *J. Inst. Civil Engrs.*, Vol. 21, Feb. 1944, pp. 227-250.

Properties of Columbium

Condensed from a Paper of the Electrochemical Society

The ores from which tantalum and columbium are extracted always contain both these elements. Pure tantalum compounds are obtained easily. To obtain a comparable degree of purity of columbium is difficult. However, a very pure columbium oxide has been obtained by using a combination of methods of purification.

(a) *Fractionation of the potassium double fluorides*: Potassium tantalum double fluoride crystallizes in fine needles. It is completely soluble in water only when the solution contains sufficient hydrofluoric acid to prevent the formation of an insoluble basic fluoride. Potassium columbium oxyfluoride crystallizes in thin plates, and is completely soluble in water containing no hydrofluoric acid.

The tantalum can be removed by crystallization in the form of needles practically free from columbium until the concentration of the columbium salt becomes high enough to deposit crystals in the form of thin plates. For further reduction, it is more efficient to use the process next described.

(b) *Formation of basic fluorides:* Potassium tantalum fluoride does not dis-

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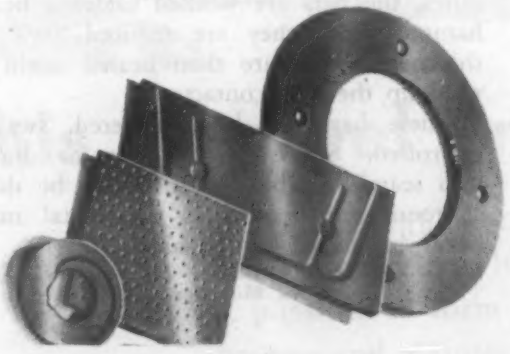

Combining a high grade bearing bronze with strip steel provides a new and unusual bearing material. Its use as SLEEVE TYPE Bearings enables manufacturers to increase speeds and loads . . . to gain longer bearing life with smoother operation . . . plus greater resistance to shock and to wear. *Pre-Cast* Bearing BRONZE ON STEEL produces a thin wall, laminated type of bearing. The fabricating process, essentially a series of stamping and forming operations provides accuracy and precision at a low unit cost.

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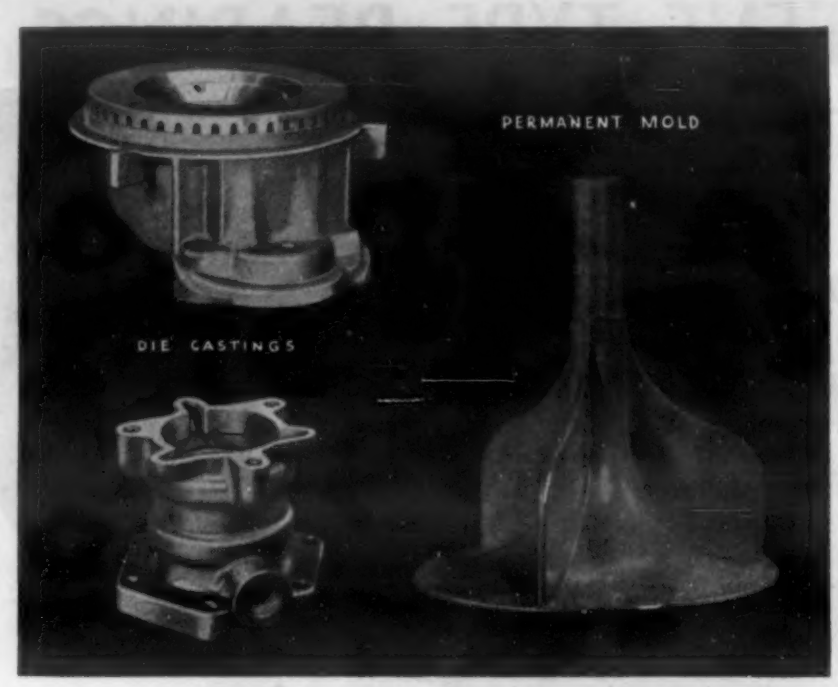

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solve completely in pure water but forms a white insoluble compound. The columbium salt does not. Therefore, the solution is boiled with an occasional addition of a base to neutralize the hydrofluoric acid formed. Basic fluorides are precipitated, and the tantalum content reduced or eliminated.

(c) *Formation of columbates:* Addition of an excess of sodium hydroxide forms sodium columbate and eliminates tin and tungsten.

(d) *Distillation:* Anhydrous columbium pentachloride may be distilled in a stream of chlorine to eliminate the elements whose chlorates boil at a temperature below 241 C.

Claire C. Balke and the author have developed a method of producing the metal that has replaced the electrolytic method formerly used. Columbium oxide of the desired purity is prepared from columbium residues. A part of this is carburized by heating an intimate mixture with lampblack in an inert atmosphere. This liberates carbon monoxide.

The carbide and oxide are mixed in a ratio giving equal atomic proportions of oxygen and carbon. This mixture, pressed into blocks, is suspended in a vacuum furnace and brought to a temperature above 1600 C. The carbon monoxide evolved is removed by pumps.

After cooling, the metal is removed as a porous ductile mass and converted to powder in a ball mill.

The powder is pressed into bar form, and these bars are heated in a vacuum by their resistance to the passage of an electric current. Vacuum pumps must have a capacity that remains high when the gas pressure becomes low. In addition to sintering the metal, this operation reduces the gas content.

Oxygen, especially, must be removed as completely as possible, because a small amount of it makes the metal harder and less easily annealed.

To compact the metal and close the pores, the bars are worked under a heavy hammer until they are reduced 20% in thickness. They are then heated again to weld up the new contacts.

These bars can be hammered, swaged or rolled. Sheet can be spun or drawn into seamless tubing. This must be done at room temperature as the metal must never be heated in the air.

—Clarence W. Balke. *Electrochemical Soc.*, Preprint No. 85-3, Apr. 1944 meeting, 6 pp.

Heat-Resisting Steels

Condensed from "The Shipbuilder & Marine Engine Builder"

In marine engineering machinery many parts have to withstand high temperature conditions of over 1000 C. (1830 F.). In coal burning boilers alloys cast iron or nickel-chromium steels with low silicon content are used for grates and fire bars.

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fired boilers are fabricated in special austenitic steels. In steam turbines, heat-resisting ferrous alloys prove most successful when exposed to superheated steam conditions both as regards production and maintenance.

Extensive use is also made of high temperature materials for high pressure control valves, nozzles and filters in steam plant and for exhaust valves and manifolds in internal combustion engines.

Various properties are necessary for high temperature marine engine conditions. The presence of alloying elements increases the creep strength of steel tenfold or more in excess of 800 C. (1470 F.). A coarse grain, such as is produced by the addition of tungsten, molydenum or other elements to austenitic heat resisting nickel-chromium steels, also aids adhesion of molecules and so prevents creep.

The presence of chromium up to 20% produces resistance to scaling up to 1025 C. (1880 F.), additions of silicon and aluminum to this alloy improves its anti-scaling properties in excess of 1150 C. (2100 F.), and nickel is added to improve the mechanical properties.

Intergranular corrosion, a most serious defect encountered in all high temperature, high pressure steam plants and in internal combustion engines, is effectively eliminated by the use of nickel-iron alloys.

The principal high temperature alloy steels used in marine engineering are stainless steel (0.42 C, 11.2 Cr, 36.5% Ni) for first and stage reaction turbine blades and for impulse turbine blades; austenitic nickel chromium steels for furnace elements, high alloyed steels (28 to 29 Cr, 20 to 22% Ni) for intensely heated furnace parts, alloy steels containing 20 Cr and 2% Ni, and silicon-chromium (3 Si, 8.5% Cr) for internal combustion engine valves.

—R. A. Collacott, *Shipbuilder & Marine Engine Builder*, Vol. 51, Feb. 1944, pp. 56-58.

Metallurgical Problems in Aircraft

Condensed from "Metal Progress"

Metallurgical problems in aircraft arise from three main sources: (a) Aircraft materials, including substitutions; (b) fabrication; and (c) assembly.

In the field of materials, the uppermost thought is that of adequate strength, commensurate with weight and ease of fabrication. Aluminum is still the predominant metal, especially in sheet form. A definite improvement in mechanical properties of the most widely used aluminum alloy (24S), by means of specific metallurgical processing, makes it inadvisable to add substitutes right at the present moment.

Quite recently new alloys of aluminum, designated as XA75S and XB75S, have been developed with higher physical properties than 24S, yet with proper corrosion resistance.

If one is to base his opinion on available published data, it will be concluded that the property of compressive strength is not of much importance to the metallurgist, yet Lockheed's chief stress engineer has

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stated that approximately 60% of aircraft parts are critical in compression!

Consideration of the artificially aged alloy 24S-T led to the necessity of spot welding certain structural parts both *before* and *after* aging. Because of this decision, it is imperative to determine the effect of spot welding on aged material as well as the effect of aging on the strength of spot-welded 24S-T.

Results on spot welding of aged material were satisfactory. Aging of spot welded samples introduces a basis for further inquiries. Comparison of shear test results showed that the effect of aging might be either positive or negative, that is, the shear strength of this material aged after spot welding may be either raised or lowered in comparison with the shear strength of the material before aging.

Formability Important

One of the highly important questions that arise when any structural material comes up for consideration is its forming properties as compared with standard alloys. The vast number of formed airplane parts can be divided as to the temper in which they are manufactured as follows: Of all parts, 50 to 60% are made of 24S-O; 10% of all parts of 24 S-W, and 40 to 30% of all parts of 24S-T. Thus, comparable evaluation of new alloys will have to be made in the condition known as "O" (annealed) and "T" (heat treated and aged at room temperature).

We have shown that "ductility" is not necessarily truly portrayed by the values for elongation in the standard sample, 0.5 in. wide, 2-in. gage length, and may be considerably re-evaluated if other gage lengths or widths of the test sample are employed. It is for this reason that we at Lockheed have adopted the practice of measuring elongation in ¼-in. gage length.

This measure, together with others, somewhat more complicated, gives a much better picture of what may be expected. In fact, comprehensive studies of forming technique have originated from the concept of a variable distribution of elongation over the conventional 2-in. gage length.

As to ferrous vs. non-ferrous alloys—generalized statements and exaggerated rumors that purport to predict the elimination of aluminum alloys and the substitution on a large scale of either magnesium or steel (including stainless) or both are, in my opinion, without foundation.

While advantage may be taken of certain characteristics of a metal, as, for example, low density of magnesium; while careful design can overcome certain disadvantages, such as thinness of steel (to satisfy strength-weight ratio)—any general change from one material to another is impossible in time of war production When the gradual introduction of a new material is justified, it is best done on a new design.

A fact of far-reaching importance is this: Steels that are successfully used in many industries do not require close control of certain of their mechanical properties. The same steels, *perfectly admissible as sound engineering material,* are not readily adaptable to the very exacting requirements of aircraft design.

—V. N. Krivobok. *Metal Progress,* Vol. 45, Apr. 1944, pp. 657-663.

The photo above shows the parachute bomb coupling forged by Phoenix for Pittsburgh DuBois Company, manufacturers of the container and suspension equipment.

WHERE SO MUCH DEPENDS ON SO LITTLE

PARACHUTE bombing has proved to be one of the most effective weapons of the Allied forces. Attached to a small parachute, the 23 pound fragmentation bomb is dropped from extremely fast, low-flying planes. The delaying action of the 'chute permits the plane to clear the area before the explosion occurs.

One of the vital parts of this assembly is the coupling, which provides the connecting link between 'chute and bomb. Any failure on its part would allow the bomb to plummet to earth immediately, resulting in a premature explosion extremely dangerous to the plane. Drop-forged by Phoenix, this coupling has the strength and stamina to withstand the sudden shock which occurs when the parachute opens, providing the extra safety factor so essential to this type of low-level bombing.

To date, Phoenix has delivered approximately 200,000 of these couplings, demonstrating their ability to meet, consistently, the rigid specifications set up for this part.

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Particle Size in Powder Metallurgy

Condensed from a Paper of the Electrochemical Society

An important problem in powder metallurgy is the determination of particle size and size distribution on powders finer than 325 mesh. Methods available for sizing fine powders may be grouped as (1) microscopic; (2) air elutriation; (3) liquid elutriation; and (4) gravitational fractionation.

Microscopic measurements are made by counting the number of particles having a predetermined size range in any single field of observation. The count is statistical, requires a trained technician, and is time consuming. The method is inaccurate, and results are difficult to interpret.

Sizing by air elutriation (separation) depends on floating the particles in an air stream of controlled velocity. By varying the velocity, particles of different size ranges can be separated out.

With perfectly spherical particles, the method is quite accurate but as few powders are even near-spherical, it is inaccurate and slow. Sizing by liquid elutriation is subject to the same general objections.

All methods of gravitational fractionation depend on measurements of time for a sample to fall a known distance in a liquid suspension and upon calculating the particle size from Stokes' law. Again, perfectly spherical particles are necessary for accuracy.

The greatest advantage is that these methods set the limits of usefulness of a powder. Those falling outside cannot be used.

Two Classes

There are two broad classes of methods. In one are sedimentation tests, where the time for a given volume of powder to fall a fixed distance is noted. The settled powder is then weighed. The size calculated is the size we would have if the particles were spherical. This is relatively accurate but slow.

The second general class covers methods where the particles, after falling some known distance, interfere with a light beam focused on a photosensitive device, causing variations in the output of the photosensitive cell. It is open to the same criticisms as the first class but can be much more rapid.

If a spherical particle of known density is allowed to fall through a liquid column at a known velocity, its diameter can be calculated from Stokes' law. With any change in particle size, the only difference will be the time required to fall a fixed distance. When the average shape is non-spherical, a correction must be applied.

If a light source and photosensitive device is placed at a fixed place along the liquid column, the change in the output of the phototube can be used for determining the time increment for each range of particles. The suspending medium will vary for different metals, and even for the same when there are marked changes in particle shape.

Standardization of the equipment is a laborious process but once this is done, accurate and rapid analyses can be made easily. It is valuable as a piece of laboratory testing equipment, for setting up standards, as well as a general production control piece of equipment.

—Philip R. Kalischer. *Electrochemical Soc.*, Preprint No. 85-15, Apr. 1944 meeting, 10 pp.

A High Density Radiographic Putty

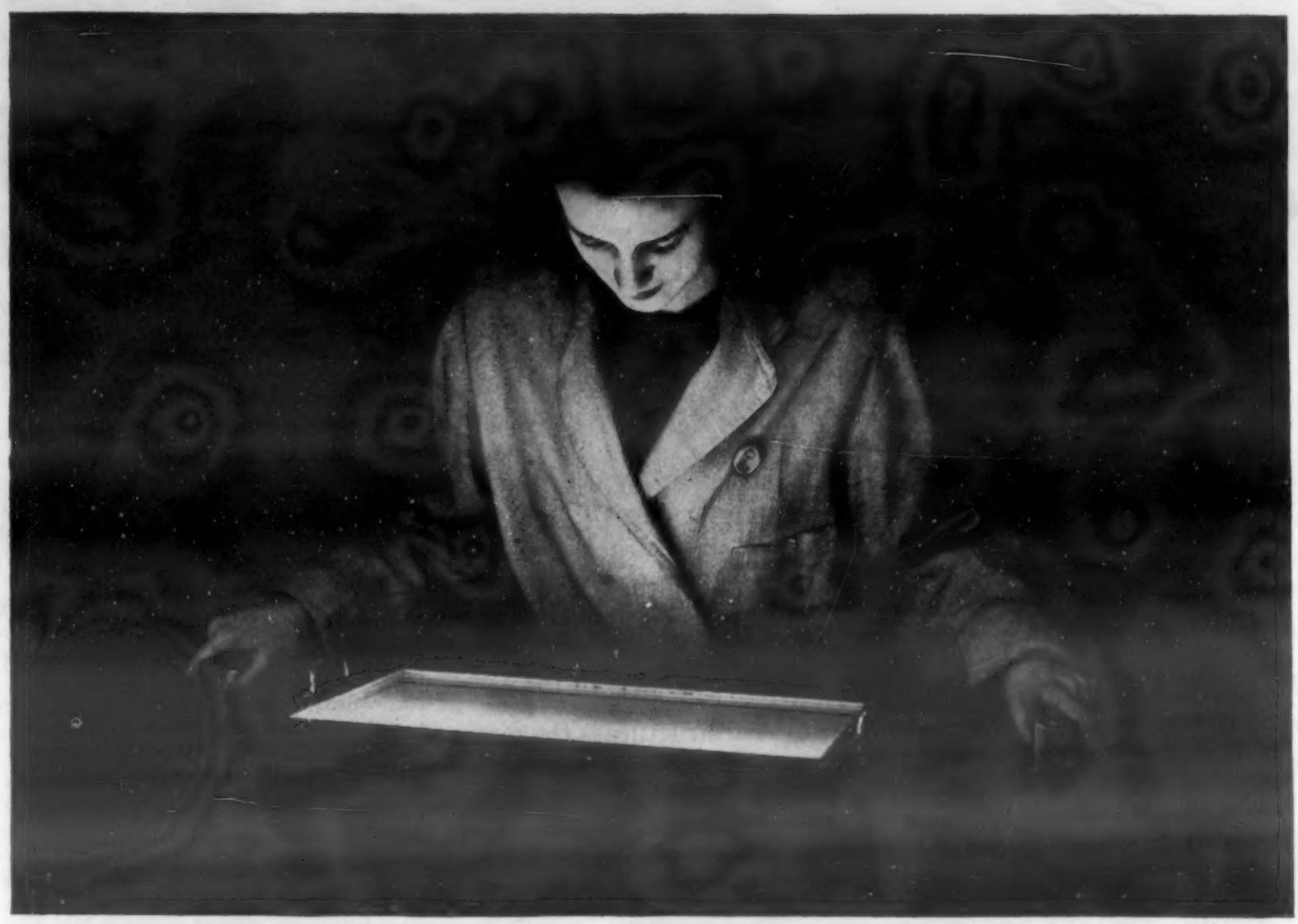
Condensed from "Industrial Radiography"

When radiographing objects of irregular thickness to correctly render any defects in the thinner portion, such a short exposure must be made that defects in the thicker portion may be entirely unrecorded. However, a plastic putty like modeling clay may be used to build up the thin sections, and may be used over and over again. The density of the putty may be varied to correspond with the metal being examined.

Chief ingredients are lead powder, bentonite and machine oil. When trying to duplicate a metal, it is best to prepare about three lots of slightly different density. Make a radiograph of each along with the work, until the best putty density is ascertained.

Lead has a density of 11.3 and bentonite

(*Continued on page* 184)



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One manufacturer reports 4,000 bars of steel tested and separated into 68 different heats in three weeks time and without delaying production!

The instrument is the Identometer. Its principle: thermo-electricity. It's portable, accurate, and fast. For a full "how it works" description, send now for Bulletin 214. DRAVO CORPORATION, *National Department*, 300 PENN AVENUE, PITTSBURGH 22, PA.

AN ELECTRICAL INSTRUMENT FOR THE INSTANT AND ACCURATE IDENTIFICATION OF MOST ROLLED OR FORGED FERROUS ALLOYS BY THE USE OF REFERENCE SPECIMENS

3.4. Between 4 and 5 parts by weight of lead powder mixed with one part of bentonite will approach steel's 7.3 density.

Metals and alloys all the way from aluminum to the heavy bronzes may be duplicated by the putty, so that 1 in. of putty will present the same radiographic density as 1 in. of the metal.

Two plates were butt welded with a purposely defective butt weld. On these plates was placed a square bar at right angles to the butt weld, and this fillet welded to the plates. The radiograph shows defects in the butt weld only on both sides of the crossing bar, but no detail in or under the bar is revealed.

Next, putty was applied and molded to a depth exactly equal to the thickness of the bar welded across the butt weld. Now the radiograph reveals defects continuously along the butt weld, defects that lie under the crossing bar and were formerly invisible. Thus, all defects may be revealed at one time and in true proportion.

A formula for mixing two substances of different density to obtain a third specified density may be found in a physics or chemistry handbook, though in practice with these particular powders some adjustments have to be made.

When making a large lot of putty, it is best to mix the dry lead powder with the dry bentonite for some time before adding the oil. When troweling the putty onto an object, be careful to avoid air pockets, which would show up as a defect in the work.

Machine oil has proved better than water or glycerine. Other high density powdered metals can be used in place of lead. Powder of 300 mesh is used in both cases.

The lead may be obtained from the Belmont Smelting & Refining Co., Brooklyn; the bentonite from the American Colloid Co., Chicago.

—B. B. Burbank. *Ind. Radiography*, Vol. 2, Winter 1943-1944, pp. 16-17.

Orientation in Brass Wire

Condensed from a Paper of the American Institute of Mining & Metallurgical Engineers

The preferred orientation in annealed 70-30 brass wire was investigated as a function of the semi-final annealing temperature (800, 950, 1100 F.), amount of cold working (47.5, 74, 83.5, 89.5%), and final annealing temperature (875, 1050, 1250 F.). The preferred orientation may be designated most simply by the fiber axis [111].

The existence of a preferred orientation was apparent in the microstructures (transverse and axial) for the final anneals at 1050 and 1250 F., and especially for all final anneals following the three greatest cold reductions. Plots made of the frequency and distribution of twin band angles with respect to the wire axis indicate that the degree of preferredness increases as the final annealing temperature and the cold reduction before the final anneal increase. The temperature of the semi-final

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anneal is of lesser importance, but there is some indication that the degree of preferredness decreases as the temperature of the semifinal anneal increases.

The preferred orientation is accompanied by significant increases in yield strength, tensile strength and modulus of electricity over the values obtaining in randomly oriented wire of similar grain size.

Although the high ductility of the more randomly oriented materials cannot be attained by the materials with strongly preferred orientation, the strength corresponding to a given value of elongation within a limited range of elongation of about 45 to 55% seems to be better for the materials that had been given the three highest amounts of cold reduction.

—H. L. Burghoff & J. S. Porter. *Am. Inst. Min. & Met. Engrs.*, Tech. Publ. No. 1688, Feb. 1944 meeting, 11 pp.

Radiography of Thin Steel Sections

Condensed from "ASTM Bulletin"

Due to unsatisfactory sensitivity at thicknesses of less than 1 in., radium radiography of steel and bronzes has been limited to thicker sections heretofore. X-rays, when available, gave greater contrast and higher speed. With new high-contrast, fine-grain film, gamma-ray radiography was tried with ½-in. steel.

Test pieces of the steel were placed at various distances from the capsule, with penetrameters indicating 2, 3, 4 and 5% of thickness. Lead screens were used, with the following films: Kodak types M, A, no-screen, and F; du Pont 506, and Agfa 674 and 874. Best results were achieved with type M, 874, 506, type A, and 674.

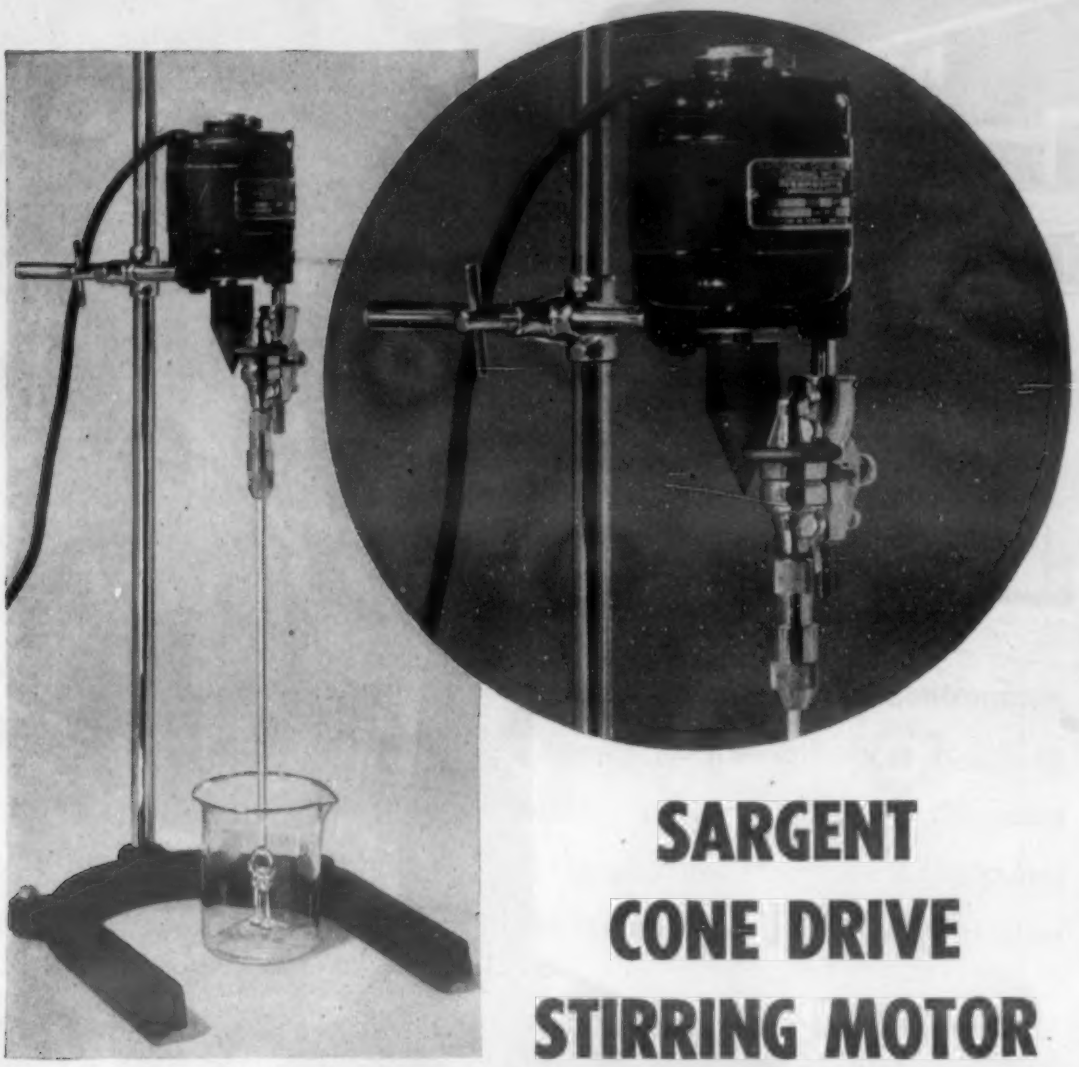
It was found that there was a minimum density for each type of film below which the penetrameter could not be seen.

Type of Film	*Penetrameters*	
	2%	*3%*
M, 874	1.3 to 1.4	1.1 to 1.2
506, A, 674	1.6	1.1 to 1.4
No-screen	2.8	1.6
F	Not obtainable	Not obtainable

An exposure factor of 130 to 150 is required for type A, 506, 674 and 874 film, while 400 to 450 would be required for type M. A small source size is a distinct advantage, since the edges of the defect will be sharper and can be more readily seen. It is not absolutely necessary, however.

While admitting that X-rays would be preferable in the radiography of thin sections of steel, there are some circumstances under which radium radiography may be necessary, such as where no machine is available, or the area to be examined is so located that X-rays cannot be used.

—A. Morrison & E. M. Nodwell. *ASTM Bulletin*, No. 127, Mar. 1944, pp. 29-30.



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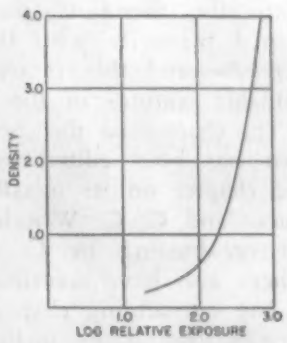

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Tungsten

TUNGSTEN. ITS HISTORY, GEOLOGY, ORE-DRESSING, METALLURGY, CHEMISTRY, ANALYSIS, APPLICATIONS AND ECONOMICS. *By K. C. Li and Chung Yu Wang. Published by Reinhold Publishing Corp., New York, 1943. Cloth, 6½ x 9¼ in., 325 pages. Price $7.00.*

Since 1915 China has been the largest producer of tungsten ore, and will probably continue so for many years to come. The senior author has for about 30 yr. been intimately connected with the Chinese tungsten mining industry. Naturally, therefore, the text is concerned primarily with the Chinese ore deposits—and this is one of the most valuable features of the book.

The chapter on the chemistry of tungsten has been edited by Zay Jeffries; the chapter on its metallurgy by E. A. Lucas and C. C. Wheeler; the chapter on ore-dressing by C. M. Dice; and others also have contributed.

The outstanding chapter, with its numerous illustrations, including color photographs, is the one on Geology of Tungsten. It is a splendid contribution to the literature of the key metal of peace and war.

The chapter on Ore-Dressing of Tungsten incorporates many of the new changes introduced during the past ten or more years. Recent war developments in the recovery of tungsten are naturally not covered.

There is a very brief chapter on the analytical chemistry of tungsten, which could profitably be extended in a future edition. The basic researches of Edgar Fahs Smith, a foremost chemist in the field, are largely overlooked. The Smith and Exner process for purifying tungsten was standard all over the world for almost 40 yr. The atomic weight value, 184, for tungsten was Smith and Exner's, and was the accepted value until a few years ago.

—COLIN G. FINK

Properties of Metals

MECHANICAL PROPERTIES OF METALS AND ALLOYS. *By J. L. Everhart, W. E. Lindlief, J. Kanegis, P. G. Weissler & F. Siegel. Published by National Bureau of Standards, Washington, D. C., 1943. Cloth, 8¼ x 10¾, 481 pages. Price $1.50.*

This is the old "Circular 101" of about 1920, now in its third revised and expanded edition. Electrical and thermal expansion properties are given, as well as mechanical properties. All commercial steels, cast irons, and nonferrous alloys, plus some special, noncommercial alloys, are tabulated, with some one of the 724 literature references cited as source of the data. Some data are given through curves.

The literature has been covered through about 1942, so that some of the data now available on N.E. steels and some recent data from the aircraft industry on special aluminum alloys, and special treatments for older aluminum alloys, are not included, but for most purposes the coverage is very complete. In leafing through it, half a dozen references turned up on a matter of current interest to the reviewer, that it would have been difficult to locate without this aid.

The subject matter is very similar to that compiled by Hoyt in his recent "Metals and Alloys Data Book." Circular 447 should stand beside it on the shelf of every metallurgical and engineering library, as primary aids to finding the sort of information they contain.

The circular is bound in boards, which is a help. The previous editions, paper bound, could not stand the hard usage they got. Most books that come to this reviewer are turned over to the library. The library will have to get other copies of this, for it stays on the reviewer's own shelves.

—H. W. GILLETT

Casting of Non-Ferrous Alloys

RECOMMENDED PRACTICES FOR THE SAND CASTING OF NON-FERROUS ALLOYS. *Published by the American Foundrymen's Association, Chicago, 1944. Cloth, 6 x 9 in., 159 pages. Price $3.00.*

This volume is the culmination of plans by the Recommended Practices Committee, Non-Ferrous Div., of the A.F.A. The recommended practice for a large number of non-ferrous alloys is described in detail and compiled by authorities in the various fields. This fact attests to their reliability and value.

Following a chapter on "Classification of Copper-Base Alloys", there are chapters covering: Leaded Red and Leaded Semi-Red Brasses, Leaded Yellow Brass, High Strength Yellow Brass and Leaded High Strength Yellow Brass (Manganese Bronze), Tin Bronze and Leaded Tin Bronze, High-Lead Tin Bronze, Leaded Nickel Brass and Bronze Alloys (Nickel Silvers), Copper-Silicon Alloys (Silicon Brass and Silicon Bronze), Aluminum Bronze, Aluminum-Base Alloys and Magnesium-Base Alloys.

Each group is discussed under molding, melting and pouring, finishing, heat treatment, defects—their causes and remedies, and properties and applications.

It can be realized from this brief description that the treatment is complete and valuable, and should be helpful and instructive to those in the sand casting of many non-ferrous alloys.

—E. F. CONE

Other New Books

MANUAL FOR ON-THE-JOB INSTRUCTION OF SCREW MACHINE PERSONNEL. *Published by National Screw Machine Products Association, Cleveland 20, Ohio, 1943. Paper, 7 by 9 in., 107 pages. Price $2.00.* This manual represents the culmination of 2 yrs. of intensive work by the Association on manpower problems. Adoption of the manual as a standard in any shop is claimed to insure more uniformity and continuity in instruction as the impact of the war has required the use of operators as teachers in many cases. These operator-teachers, by following the "key points" of the manual, will not overlook some small step that might later cause trouble by having been omitted. The manual presents easily-understood instructional material in a highly original manner, covering all types of multiple spindle automatics, extensive data on grinding and setting tools, and so on.

QUIN'S METAL HANDBOOK AND STATISTICS. *By F. B. Rice-Oxley. Published by Metal Information Bureau, Ltd., London, England, 1943. Cardboard 6 x 4 in., 320 pages. Price 10 shillings ($1.50).* The publication of this authoritative international reference book on ores, metals, scrap, etc., is now in its 30th consecutive year. For the first time it is divided into two sections: The first is statistical, covering prices, imports, exports, production and consumption of metallic ores, etc. The second, a new feature, is a monograph on the properties, uses and commercial grades of non-ferrous ores, notes on specifications and uses of copper and copper alloys, and a brief summary accompanied by charts of the method and procedure of the manufacture of steel. Minor metals are the subject of another topical feature which gives details of their properties, uses, commercial forms and methods of sale. Reference tables of weights, sizes, gages and physical constants of various metals and metal products are included.

METALLURGICAL ENGINEERING news

Equipment • Finishes • Materials • Methods • Processes • Products
Alloys • Applications • Designs • People • Plants • Societies

Two Grinding Accessories

Two new related products, the "DoAll" electro-magnetic chuck and "Selectron," are announced by *Continental Machines, Inc.*, 1301 Washington Ave., South, Minneapolis 4. The Selectron is a revolutionary new current rectifying and demagnetizing unit. The combination of chuck and Selectron improves and eases difficult grinding operations.

The amount of magnetic pull of the chuck holding the work is under the operator's control. The Selectron uses electronic power to control the flow of magnetic pull

in the chuck, and to demagnetize it when work is to be removed. The chuck's working surface is ground to mirror finish, with sides and ends square and parallel.

The electronic device uses tubes for the full wave rectification of alternating current in supplying direct current to the chuck. Demagnetizing requires but a few seconds. The work is easily removed from the chuck without pulling it against residual magnetism. All sides can be ground to high finish without scratching when removed from the chuck.

Variable control of magnetic current permits accurate grinding of thin, flat work that may be warped from heat treatment. Only enough current is used to hold the work, thus allowing distortion to be ground off.

Salt Bath for Cartridge Cases

A novel electric salt bath furnace for heat-treating cartridge cases has been completed by *Upton Electric Furnace Div.*, 7450 Melville, at Green, Detroit. Having a pot size of 21 ft. long by 56 in. wide, with working depth of 21½ in., it will be used to full anneal cases continuously.

A feature is the correct spacing of sealed electrodes and proper application of current. Electrodes extend through from the outside of the furnace where connection is made to transformers. Their inside surface is flush with the bricking that forms the interior surface of the walls and floor of the pot itself.

The absence of electrodes extending from above the surface of the salt down into the

bath eliminates the possibility of shorting and burning the work. Heat is generated in the salt at the furnace bottom so that a normal circulation of heated salt exists throughout the furnace.

Molten salt will be held at 900 F. Power is by 3-phase a.c. connected to six transformers, connected in turn to the six electrodes, the transformers being used in pairs. An offset at the far end of the furnace permits a conveyor to return the work through the bath without lifting it out of the molten salt.

DURALOY

HIGH ALLOY CASTINGS

Properly Alloyed
Correctly Poured
and Heat-Treated

Specialists in high alloy castings are here at Scottdale . . . with twenty odd years experience in the selection of the alloying elements and production of sound castings . . . and modern facilities to produce chrome-iron and chrome-nickel castings.

If your equipment is operating under difficult conditions of corrosion, high temperatures and abrasion, investigate the use of chrome-iron or chrome-nickel castings to meet these conditions. For tubular products requiring a denser, stronger, more uniform metal, consider the use of DURASPUN CENTRIFUGAL CASTINGS.

We can produce castings in any size from a pound or so up to four tons in weight, with the correct proportion of alloying elements. Consult us on your requirements. Our metallurgists may be able to render valuable advice that will help to solve your problem.

THE DURALOY COMPANY

Office and Plant: Scottdale, Pa.

Eastern Office: 12 East 41st St., New York 17, N. Y.

Chicago and Detroit
F. B. Cornell & Associates

Los Angeles
Kilsby & Graham

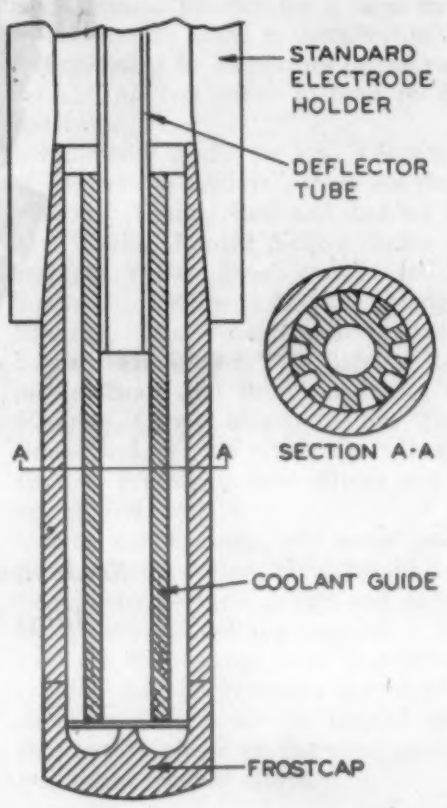
Scranton, Pa.
Coffin & Smith

Metal Goods Corp.: St. Louis — Houston — Dallas — Tulsa — New Orleans — Kansas City

7-DU-1

Self-Adapting Coolant Electrode

A self-adapting "Frostpoint" spot welding electrode, eliminating adaptors, for standard electrode holders, is introduced by *Frostrode Products,* 19003 John R., Detroit 3. Adaptors had been used to separate the refrigerant in the "Frostpoint" from the water circulation in the electrode holder for welding in the zero range. They are still efficient, but the widespread use of "Frostpoints" for spot welding even above the zero range called for a simplified design.



The new electrode provides complete interchangeability with conventional electrodes. Though intended primarily for refrigerated coolants, it is better with water cooling than the conventional spot welding electrode. "Frostpoints" are equivalent to 60 F. colder water.

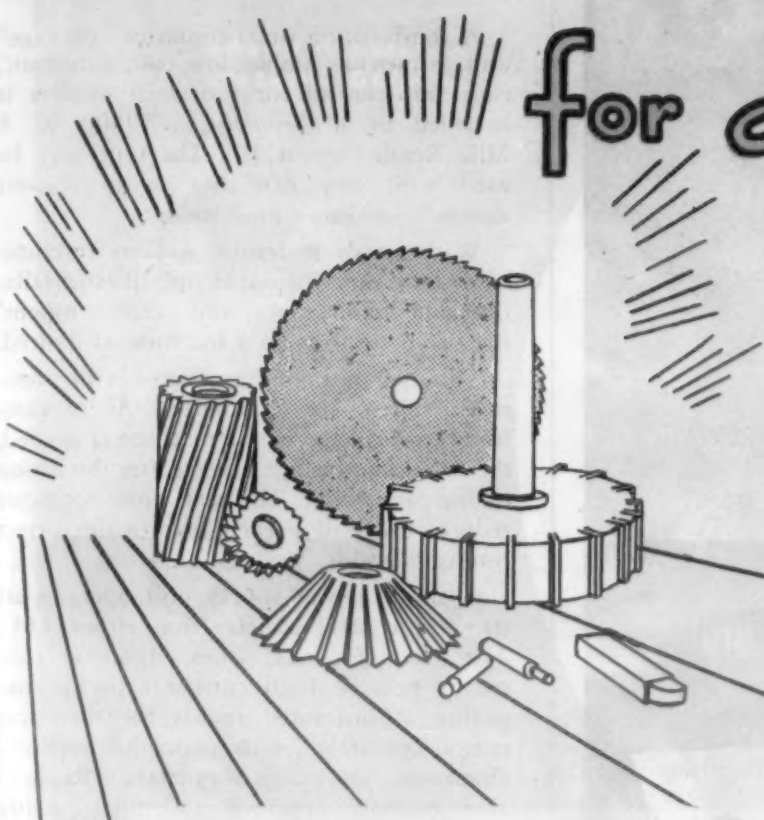
Elimination of adaptors is desirable where clearances for electrodes are close, such as flanges, over-hangs, channels, etc. Here the new electrode eliminates interference from coolant lines.

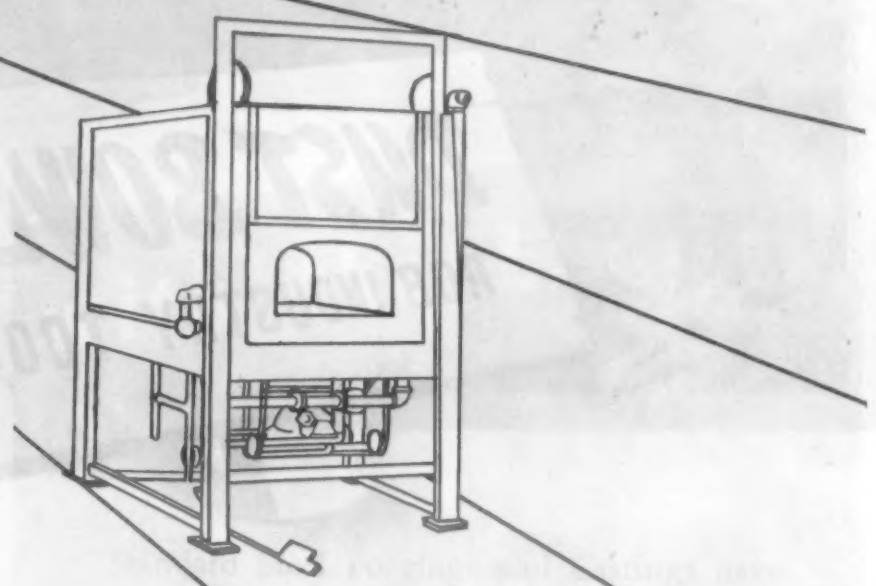
When inserted in a standard electrode holder, the deflector tube is engaged by a full-length coolant guide providing a metered flow of the coolant through the internally finned "Frostcap." Return flow is through many parallel passages, allowing extensive metal surfaces to contact the coolant.

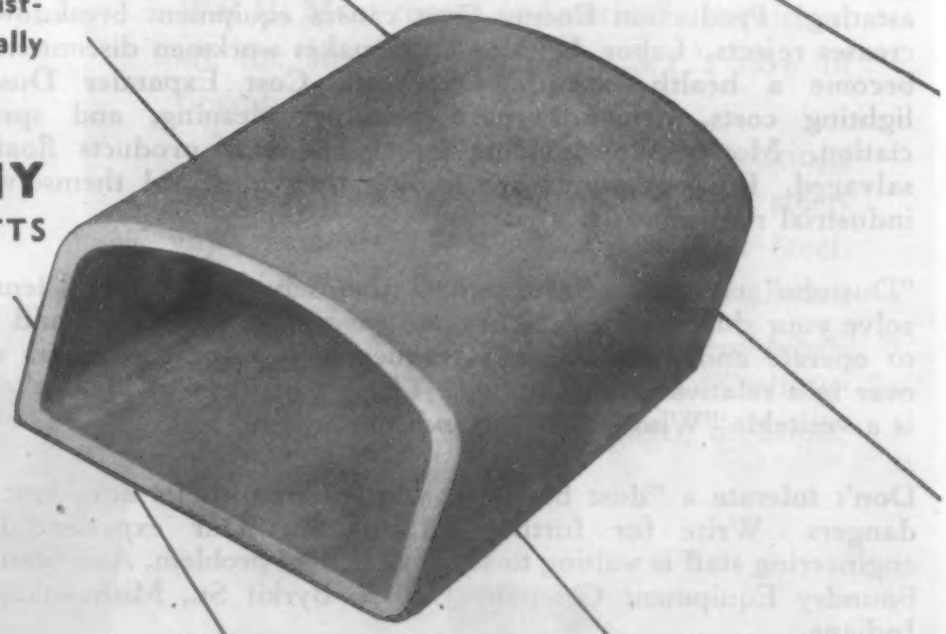
● The "marriage" of plasticized vinyl chloride resins with certain butadiene-type synthetic rubbers to effect vulcanizable blends that possess most of the best properties of each material, creating a valuable series of elastomers, is announced by *B. F. Goodrich Co.,* Akron, Ohio. Among many suggested uses are plating racks and tank linings, where they resist corrosives and heat, and roll coverings in continuous metal processing lines. ●

NORTON REFRACTORY MUFFLES

for Heat-Treating Efficiency





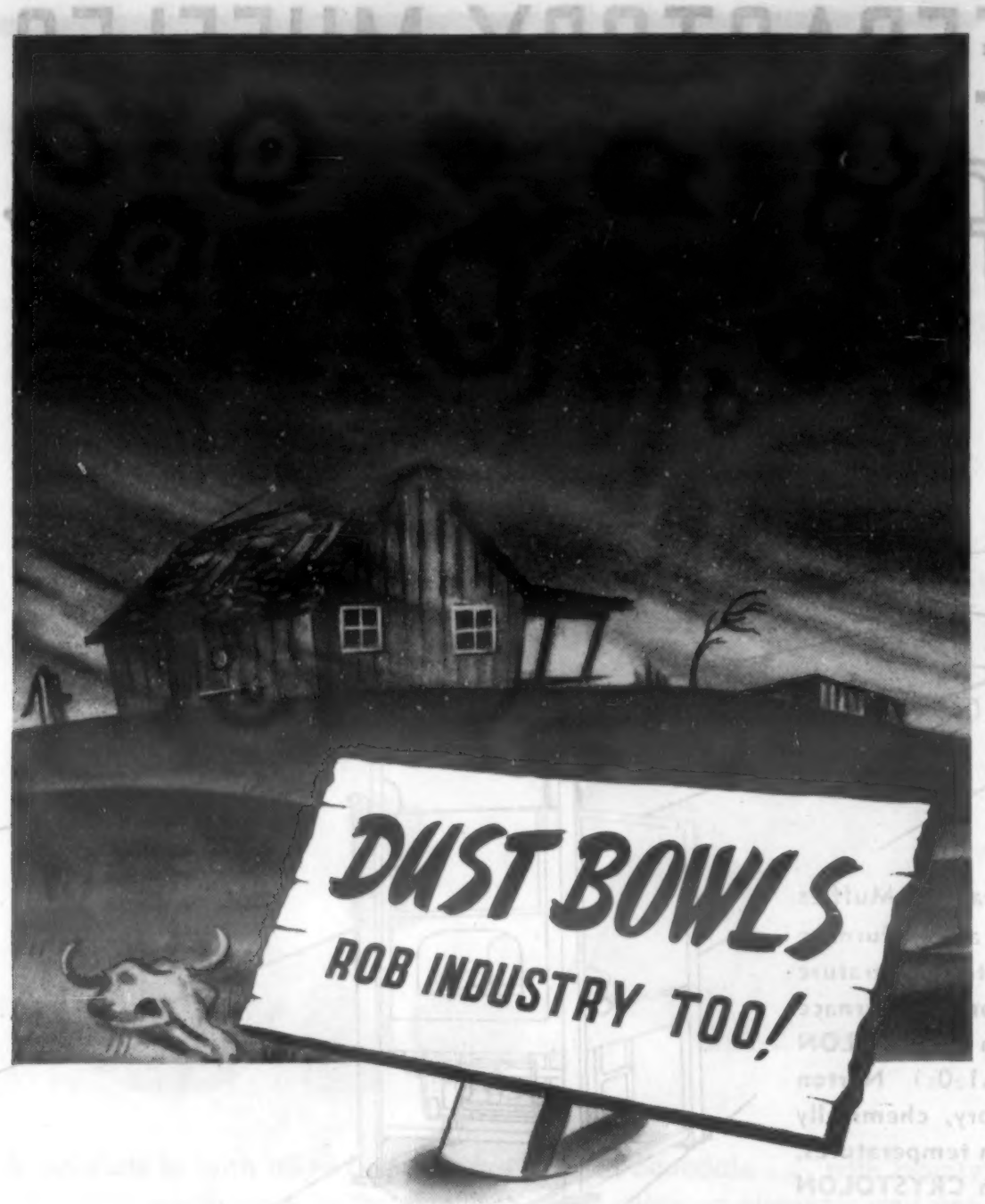


THE ability of Norton Refractory Muffles to transfer heat readily allows furnace and work to be brought up to temperature quickly and assures economical furnace operation. Available in both CRYSTOLON (SiC and ALUNDUM (Al_2O_3) Norton muffles are highly refractory, chemically inert under exceedingly high temperatures, and physically rugged. Both CRYSTOLON and ALUNDUM muffles are suited for electric furnaces — although ALUNDUM cement, because of its higher electrical resistance at elevated temperatures, is generally used for embedding the resistor wire.

R-871

NORTON COMPANY
WORCESTER 6, MASSACHUSETTS

Norton Longer Lasting Refractories



DUST bowls in industrial plants aren't spectacular but . . . they are devastating! Production Enemy Dust causes equipment breakdowns and increases rejects. Labor Agitator Dust makes workmen discontented and can become a health hazard. Overhead, Cost Expander Dust increases lighting costs, demands more painting, cleaning, and speeds depreciation. Money Waster Dust lets valuable by-products float away unsalvaged. Efficient plants are finding they must rid themselves of these industrial robber dusts.

"Dustube" collectors have proved themselves a most efficient means to solve your dust problem. They are easy to install, simple and inexpensive to operate and maintain, and frequently pay for themselves many times over in a relatively short period. The list of users of "Dustube" collectors is a veritable "Who's Who" in industry.

Don't tolerate a "dust bowl" in your plant with its attendant losses and dangers. Write for further information. Our experienced engineering staff is waiting to solve your dust problem. American Foundry Equipment Company, 510 S. Byrkit St., Mishawaka, Indiana.

ARMY NAVY
AMERICAN dustube
dust collectors

Electronic Control for Resistance Welders

A combination timer-contactor "package" unit to provide simple, low cost, automatic, electronic control for resistance welders is heralded by *Weltronic Co.*, 19500 W. 8 Mile Road, Detroit 19. The unit may be used with new machines or to convert manually or cam-timed welders.

With air or hydraulic welders it eliminates inter-unit wiring, it simplifies installation and maintenance, and permits mounting of all controls on a machine, if desired.

Variables normally associated with pneumatic timers are eliminated. As to cam-timers, no change in the machine is needed, the electronic timing superceding the action of the cam timer. The new timer-contactor reduces the skill needed to provide correct timing of welds.

A single power supply unit operates all standard control panels from either 115-, 230- or 460-v. a.c. lines. Ignitron contactors provide high current capacity contacting at unlimited speeds for the most critical operations, such as on thin sections, aluminum and alloyed metals. Replaceable contacts mounted on quick acting armatures minimize maintenance.

● A very adaptable and simple dust suppressor, Type "GA" Hydro-Clone, for individual grinders, polishers, etc., is announced by *Whiting Corp.*, Harvey, Ill. Compressed air creates a powerful suction on the hoods and mixes dust laden air with water, settling as sludge. As an alternate to compressed air, a centrifugal pump is furnished to recirculate the water.

Induction Heating Unit

A new 25 kw. Megatherm induction heating unit for high-speed surface hardening of bearing surfaces, cam faces, gear tooth contours; for brazing and silver soldering; for speedy heating of brass, copper and aluminum alloy pieces as well as steel, is introduced by the *Industrial Electronics Div., Federal Telephone & Radio Corp.*, 28 Halsey St., Newark, N. J.

It uses frequencies between 2 and 5 million cycles per sec. The heating fixture is a simple coil of from one to five turns that can be constructed readily from standard copper tubing. The overall efficiency equals or exceeds 50%.

The power factor of Megatherm is 95%. Average operating cost is 50c per hr. The cabinet measures 4 by 4 by 7 ft.

● Coleman certified buffer tablets, covering the region 2.0 to 12.0 pH in steps of 0.20 pH, are now offered by *Burrell Technical Supply Co.*, 1936 Fifth Ave., Pittsburgh 19. A solution is prepared by dissolving one tablet in 100 ml. of warm distilled water, when the pH will be exact.

BALDWIN-BUILT
STEERING GEAR

STANDARD with the L.S.T.

Standard Steel Forgings and Castings have found more than one part to play in World War II. Most recent and critically important are the steering gears on L.S.T.'s now in operation by the U. S. Navy.

Many of the steel forgings and castings in these specially designed quadrant steering gears are products of Standard Steel.

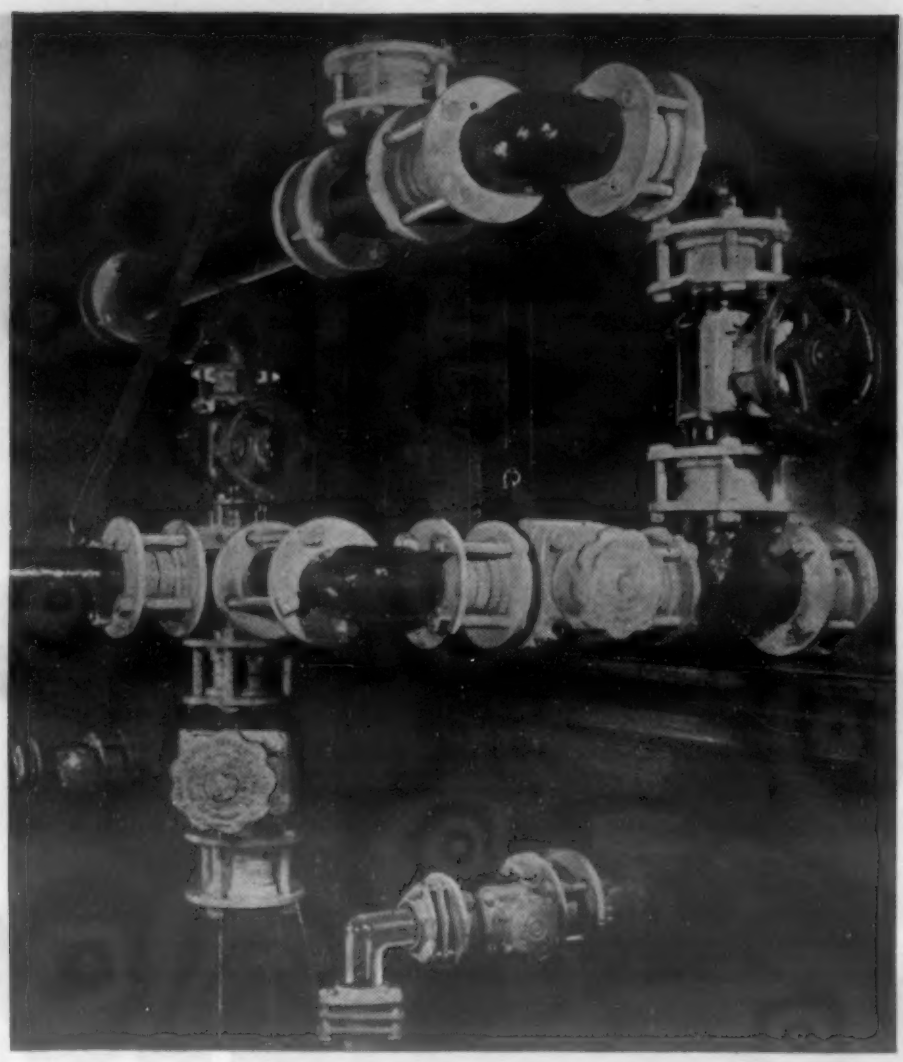
The Baldwin Locomotive Works, Standard Steel Works Division, Burnham, Pa., U.S.A. Offices: Philadelphia, New York, Washington, Boston, Cleveland, Chicago, St. Louis, Houston, San Francisco.

ARMY E NAVY

BLW THE BALDWIN GROUP

BALDWIN
STANDARD
STEEL FORGINGS & CASTINGS

HAVEG



Plastic Piping • Valves Fittings • Fume Duct for acids and alkalies

Completely chemically resistant throughout its entire mass, HAVEG provides efficient means of handling corrosive liquids and fumes. HAVEG piping and fittings are stocked in standard sizes from ½″ to 12″ I. D. inclusive. HAVEG fume duct is made in standard sizes 2″ to 36″ I. D. inclusive. Standard and Special Fittings and Valves are available to meet specific problems. Bulletin F-3 gives complete design, application and chemical resistance data. Send for a copy today.

HAVEG-SARAN *Tubing; Pipe & Fittings; and sheets are available from stock.* **HAVEG-SARAN** *is also described in Bulletin F-3. Send for a copy now.*

HP-

HAVEG CORPORATION
NEWARK, DELAWARE
FACTORY–MARSHALLTON, DELAWARE

CLEVELAND 14
550 Leader Building

CHICAGO 11
1201 Palmolive Building

DETROIT 11
2832 E. Grand Blvd.

LOS ANGELES 13
601 W. Fifth St.

Marking With Draw Dies

An improved method for marking numbers on deep drawn steel and other parts at no additional cost makes use of precision engraved knockout pads produced by *New Method Steel Stamps, Inc.*, 147 Jos. Campau, Detroit 7. The figures are engraved on the upper surface of the pad itself, thus making the one piece a combination of knockout pad and marking die.

When in use, the knockout pad is backed by springs. It numbers the bottom portion of the stamping during the actual drawing and then lifts the finished piece out of the die after the male half of the forming die has been withdrawn.

A feature of this automatic marking of parts is that it eliminates possible errors.

● A tape for insulating plating racks and for use as a stop-off, called Wrap-Rax, has been brought out by the *Hanson-Van Winkle-Munning Co.*, Matawan, N. J. It is a synthetic thermoplastic resin in tape form, highly resistant to abrasion and of good dielectric properties. It can be used for repairing and patching old racks.

Hydraulic Production Drilling Units

A new special hydraulic production drilling unit that can be arranged for drilling, reaming, facing, boring, counterboring or tapping operations in any one, or combination, of horizontal, vertical or angular positions, is sponsored by the *Barnes Drill Co.*, 814 Chestnut St., Rockford, Ill. The unit is available in three sizes.

The low cost, high production possibilities of these machines are almost unlimited, state the makers. They can be furnished suitably mounted on the proper columns, horizontal beds, supports, hydraulic indexing tables and other elements as a machine complete in itself.

A conveyor automatically removes chips from the indexing table. All controls are located on one side of the unit. The units can quickly and economically be converted to future requirements.

"City in the Sky"--the Mercantile Bank Building, Dallas, Texas. Youngstown Pipe used for plumbing, heating and air-conditioning. Architect, Walter W. Ahlschlager, general contractor, Henger Construction Co., plumbing sub-contractor, C. Wallace Plumbing Co. -- all of Dallas.

If Dallas depended on this Egyptian Chain of Pots

THE citizens of Dallas take justifiable pride in this new skyscraper . . . the 30-story Mercantile Bank Building.

Yet who appreciates that this "City in the Sky" was possible only because of the availability of modern piping systems--the only practical means to service every floor of its magnificent 30 stories with water.

Imagine what this building, housing thousands of workers, would be like with no water or modern heating facilities. Picture the impossibility of this structure in Ancient Egypt, dependent on the then ultra-convenient chain of earthenware pots to draw water from wells.

In order to live in cities, civilized men must have water close at hand . . . and to have water we must have dependable pipe . . . pipe low enough in cost so that it can be used plentifully, pipe durable enough that it will withstand the ravages of time and the hardships of extraordinary service. Steel pipe is the answer to all of these requirements.

The architect who specified Youngstown Pipe for this job and the contractor who bought and installed it, know of its enviable record in other outstanding installations.

YOUNGSTOWN

THE YOUNGSTOWN SHEET AND TUBE COMPANY

YOUNGSTOWN 1, OHIO

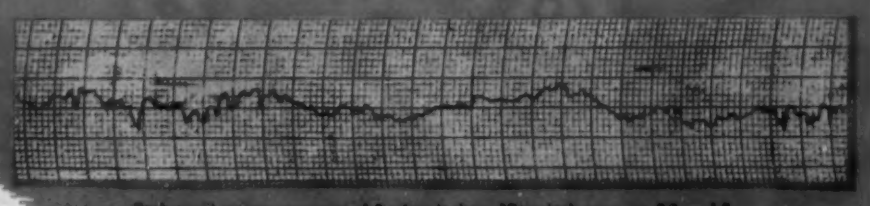
Manufacturers of

Carbon, Alloy and Yoloy Steels

QUALITY YOUNGSTOWN SERVICE

Pipe and Tubular Products - Sheets - Plates - Conduit - Bars - Coke Tin Plate - Electrolytic Tin Plate - Rods - Wire - Nails - Tie Plates and Spikes.

Proof of a Better Finish



Surface Analyzer Tape Proves You Get a Better Finish With Chicago Wheels

These results were obtained at a rate of 10 pieces per hour in an aircraft parts plant. Material, X-13-15, Rockwell 60 to 57, grinds out .006 to .007 stock. Chicago Wheel used, ½ x ½ x ⅛", Grain 180, Grade L Arcite FV Bond. Spindle Speed 40,000 r.p.m. Lapping and super finishing eliminated on this job.

Can you match that finish? Sounds phenomenal, but you can do it with Chicago Wheels. And, the secret of their superiority lies in the new FV Bond, developed exclusively for Chicago Wheels, after 50 years' experience making wheels for the most accurate and precise applications.

Here's What FV Bond Will Do for You

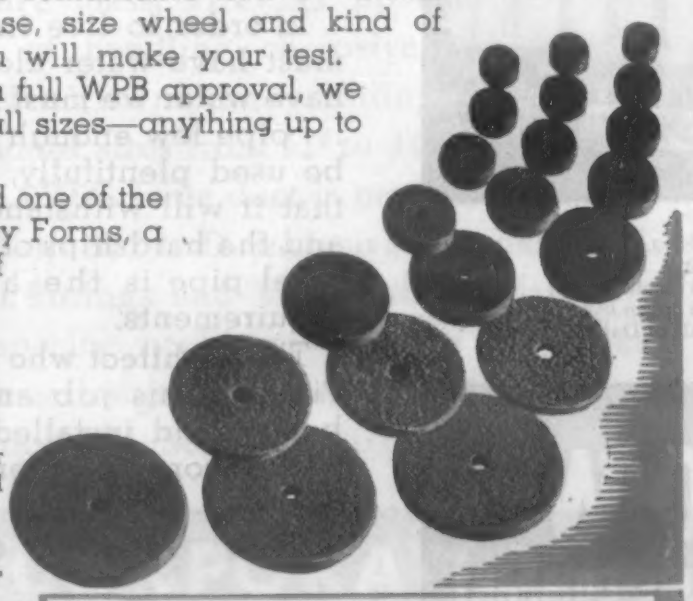
* Reduce your wheel costs
* Produce a better finish without sacrifice of production time—a finish so smooth that you can measure it in micro inches.

TRIAL WHEEL FREE

Write or send the coupon today for a Chicago Wheel, made with this remarkable new FV Bond. Tell us grinder you use, size wheel and kind of material on which you will make your test.

For the duration, with full WPB approval, we are specializing on small sizes—anything up to 3" in diameter.

Write for Catalog and one of the new Engineering Survey Forms, a step in the direction of better finishing.



CHICAGO WHEEL & MFG. CO.

America's Headquarters for Mounted Wheels and Small Grinding Wheels.

1101 W. Monroe St., Dept. ME. Chicago 7, Ill.

Half a Century of Specialization has Established our Reputation as the Small Wheel People of the Industry.

ME-7

Send Catalog and Survey Form. Interested in
( ) Mounted Wheels. ( ) Grinding Wheels.
( ) Send Test Wheel. Size.....

Name.....

Address.....

Heat-Resistant Thermoplastic

A new thermoplastic that can hold its shape and strength in boiling water, yet can be molded fast and economically, is announced by *Monsanto Chemical Co.*, St. Louis 4. Known as "Cerex," it should have many industrial and household applications because of its ability to withstand high temperatures.

It has already found wide use in war work, particularly Radar, radio and electronic equipment where light weight, suitable electrical and heat-resistant properties are desirable. Dr. Charles Allen Thomas, director of Monsanto Central Research Laboratories, describes Cerex as a:

"Thermoplastic, readily moldable in standard molding machines, and combining high resistance to heat with resistance to strong, corrosive chemicals, excellent electrical insulating properties and high rigidity and strength."

It has been subjected to boiling sulphuric acid solution without effect. It has also withstood conditions that corroded enameled steel and attacked the surface of aluminum.

● An entirely new technique in producing holes is introduced by *Shearcut Tool Co.*, Bendix Bldg., Los Angeles. The method is called rotary broaching, since the tool is in effect a broach that rotates as it cuts. It removes metal by a true shear-cutting knife action, the chips resembling steel wool. There is no tendency to produce elliptical or uneven holes.

Combination Etcher and Demagnetizer

A new tool that serves as either etcher or demagnetizer is introduced by the *Ideal Commutator Dresser Co.*, 1928 Park Ave., Sycamore, Ill. To etch small tools and parts one simply places them on the work plate, turns the switch "on" to the proper heat. A ground clamp is provided for etching parts too large for the work plate.

Fourteen heats are provided by "Hi-Lo" tap and 7-point switch, thus giving a wide range for marking all iron, steel and their alloys from small delicate parts up to large smooth castings. An indicating lamp grows brighter as each higher heat is used.

To demagnetize, one turns the switch "on," to either No. 1 or No. 2 position, and proceeds as with an ordinary demagnetizer. Maximum rating is 5.5 amp. The overall pole area is 13½ sq. in.

● A new insulating "Fireblok" is announced by *Johns-Manville Corp.*, 22 E. 40th St., New York, a feature being that one fireblok will cover more surface than five full-sized fire brick. It comes in four grades, standing temperatures from 1600 to 2600 F.

SEYMOUR NICKEL SILVER

ALLOY	Alloy No.	Form	Composition Approximate Percent Copper	Zinc	Nickel	Lead	Tensile Strength lbs. per sq. in. Hard to Spring	Soft	Elongation Percent in 2 ins. Hard to Spring	Soft	Rockwell Hardness Hard to Spring	Soft	Density (Specific Gravity) @°C	lbs. per cu. in.	lbs. per cu. ft.	Melting Point °F	Elect. Resist. I.A.C.S.	Elect. Conductivity I.A.C.S. 20°
5%-GRADE A	5	Wire	61.00	34.00	5.00		135,000	50,000	2.									12.0
10%-GRADE A	10A1	Sheet	67.00	23.00	10.00		109,000	52,000	1.5	40.	88.	32.	8.64	.312	539	1910	11.1	9.0
12%	12X1	Sheet	61.00	26.00	12.00	1.00	90,000		5.		87.							
12%	12X1	Rod	61.00	26.00	12.00	1.00	82,000	53,000	7.									
15%-GRADE A	15A	Sheet	64.00	21.00	15.00		93,000	58,000	5.	40.	90.	35.	8.70	.314	542	1965	15.9	6.3
15%-GRADE B	15B	Sheet	58.00	27.00	15.00		100,000	55,000	2.	36.	94.	37.	8.62	.311	537	1900		
15%-F.T.	15X1	Rod	60.00	24.00	15.00	1.00	85,000		10.		80.						16.7	6.0
18%-GRADE A	18A3	Sheet	65.00	17.00	18.00		100,000	54,000	3.	40.	90.	38.	8.75	.316	545	2030	16.7	6.0
18%-GRADE A	18A3	Wire	65.00	17.00	18.00		120,000	55,000	3.	40.			8.75	.316	545	2030	16.7	6.0
18%-GRADE B	18A4	Sheet	55.00	27.00	18.00		110,000	60,000	2.	45.	95.	40.	8.68	.313	541	1940	18.2	5.5
18%-GRADE B	18A4	Wire	55.00	27.00	18.00		145,000	62,000	3.	50.			8.68	.313	541	1940	18.2	5.5
18%-F.T.	18X1	Rod	62.00	19.00	18.00	1.00	85,000		13.		80.						17.6	5.7
18%-SPECIAL	18A7	Sheet	75.00	7.00	18.00		85,000	50,000	4.	32.	88.	25.	8.83	.319	550	2090	16.2	6.2
		Rod	75.00	7.00	18.00		80,000	55,000	7.	45.								
		Wire	75.00	7.00	18.00		115,000	55,000	2.	30.								
25%		Sheet	56.00	19.00	25.00		110,000	72,000	4.	30.	94.	60.					23.8	4.2
15%-CUPRO NICKEL		Sheet	85.00		15.00		70,000	45,000	3.	30.	83.	34.				2065	12.2	8.2
20%-CUPRONICKEL		Sheet	80.00		20.00		85,000	50,000	2.	30.	85.	37.5	8.85	.320	552	2100+	15.4	6.5

AVAILABLE IN	Gage Range (inclusive)	Width Range (inclusive)
SHEET	16-36 B&S	Rods up to 2" Sheets up to 40"
CIRCLES	16-28 B&S	
COILS (STRIP)	16-36 B&S	
WIRE	4-30 B&S	
WIRE (FLAT)	8-30 B&S	
ROD	2"-1/32"	

MISCELLANEOUS

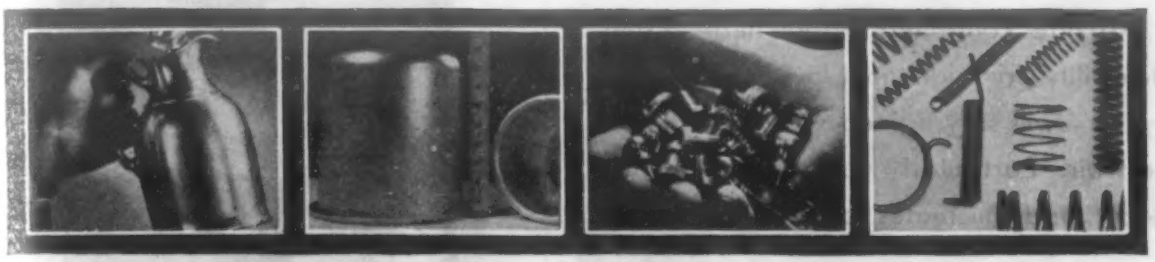
WIRE AND ROD supplied Round, Half-Round, Quarter-Round, Oval, Half-Oval, Hexagon, Octagon, Square, Triangular, or Fancy - tinned or bare.

SHEET AND STRIP in roll finish or Patent Level. Strip tinned if desired.

SILVERY WHITE COLOR

EVEN GRAIN

BE SURE YOU'RE USING THE RIGHT MATERIAL



WIDE DUCTILITY RANGE

It May Pay to Recheck Your Designs

Specifying materials correctly may sometimes be a difficult habit to acquire but it often pays to do so. The demand for Seymour Nickel Silver has grown steadily since World War I. Wars sharpen wits, unseat old customers. It is now established that the versatility of Seymour Nickel Silver can far outweigh its slight extra cost. As a base for silver, nickel or chrome plate, it has no superior. Its ductility range is a joy to the spinner and stamper. Its corrosion resistance is remarkable. A table of characteristics is given above.

EASILY SPUN OR FORMED

Our present output is confined to the war effort. Nevertheless, check over the characteristics of Seymour Nickel Silver with an eye to improving your present war products or peace products that are still in the planning stage.

THE SEYMOUR MANUFACTURING CO.
63 FRANKLIN ST., SEYMOUR, CONN.

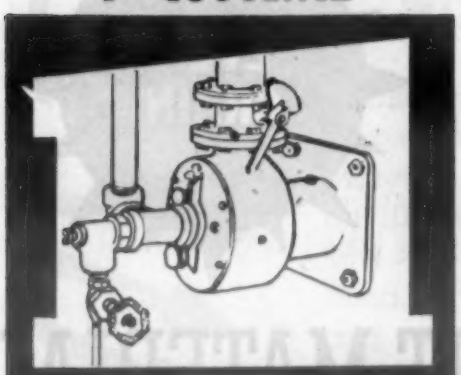
CORROSION RESISTANT

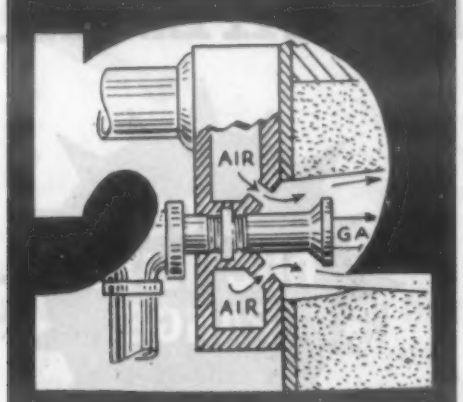
LEADED *for* FREE CUTTING

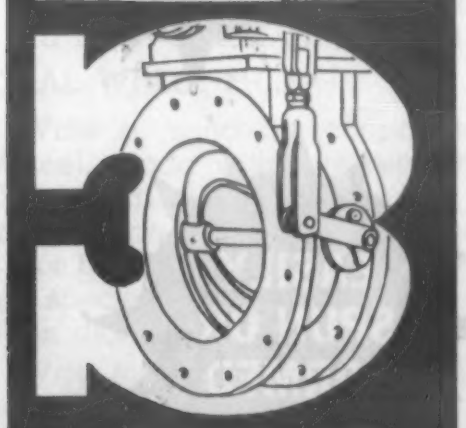
NON-FERROUS ALLOYS Since 1878

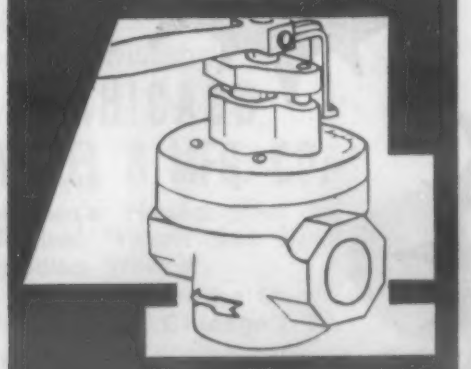
Four BLOOM "Firsts"

ENGINEERED TO SIMPLIFY YOUR INDUSTRIAL COMBUSTION *Problems*









LONG FLAME BURNER

Provides quick change from gas to oil or oil to gas without sacrificing uniform heating conditions, and with less consumption of fuel. No shutdown or delay. Over 7500 satisfactory installations.

TEMPERED FLAME COMBUSTION

Provides controlled uniform heating and flexibility for high and low temperature cycles—will stay lighted with 1000% excess air. Particularly valuable where furnace load fluctuates over wide range.

BLOOM REDUCED PORT BUTTERFLY CONTROL VALVES

Manual, motor or hydraulic operation. Port sizes to suit flow needs. Non-sticking valve plates. Lubricated shaft bearings. Close machining suitable for 40 to 1 turndown.

CALIBRATED-FLOW OIL VALVES

Provide accurate and uniform control of heavy liquids such as tar or heavy oil. Manual or motor operated—only one moving part.

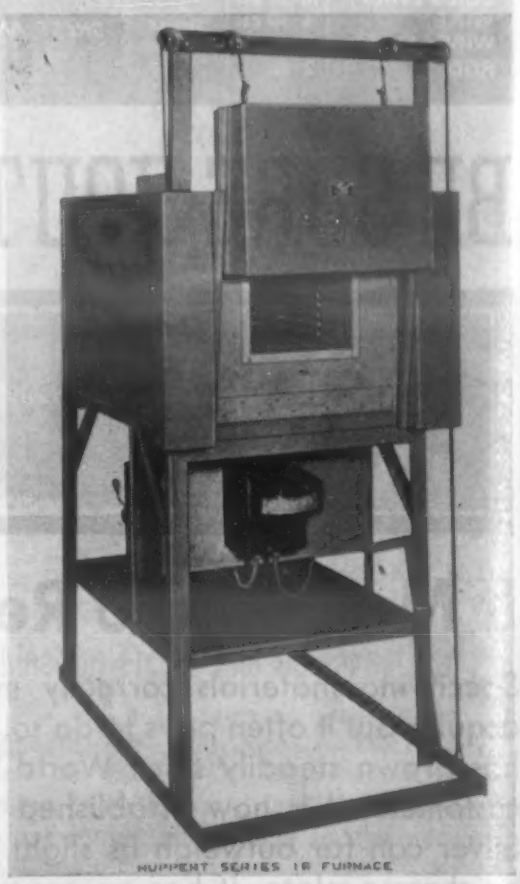
Bloom engineers are available anywhere, anytime for consultation on combustion problems.

BLOOM ENGINEERING COMPANY
857 W. NORTH AVENUE PITTSBURGH 12, PA.

● A new coated aluminum-bronze electrode, No. 200, has been introduced by the *Wilson Welder & Metals Co.*, 60 E. 42nd St., New York 17. It is a shielded arc electrode, and can be used as a filler rod in carbon arc welding. It is claimed superior to standard manganese bronze as to corrosion resistance and equal in strength, hardness and ductility. It welds most bronzes, malleable and cast iron or steel, and can function on dissimilar metals.

Floor Model Heat-Treat Furnaces

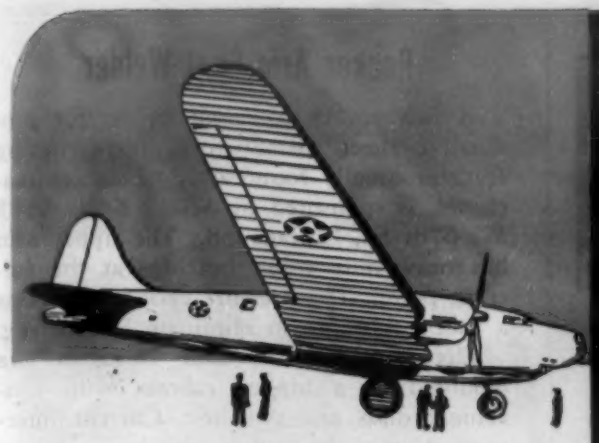
A new series of floor model heat treating furnaces, with five basic designs, is being marketed by *K. H. Huppert Co.*, 6830 Cottage Grove Ave., Chicago 37. Variations among the five deal particularly with the inside depth of the furnace.

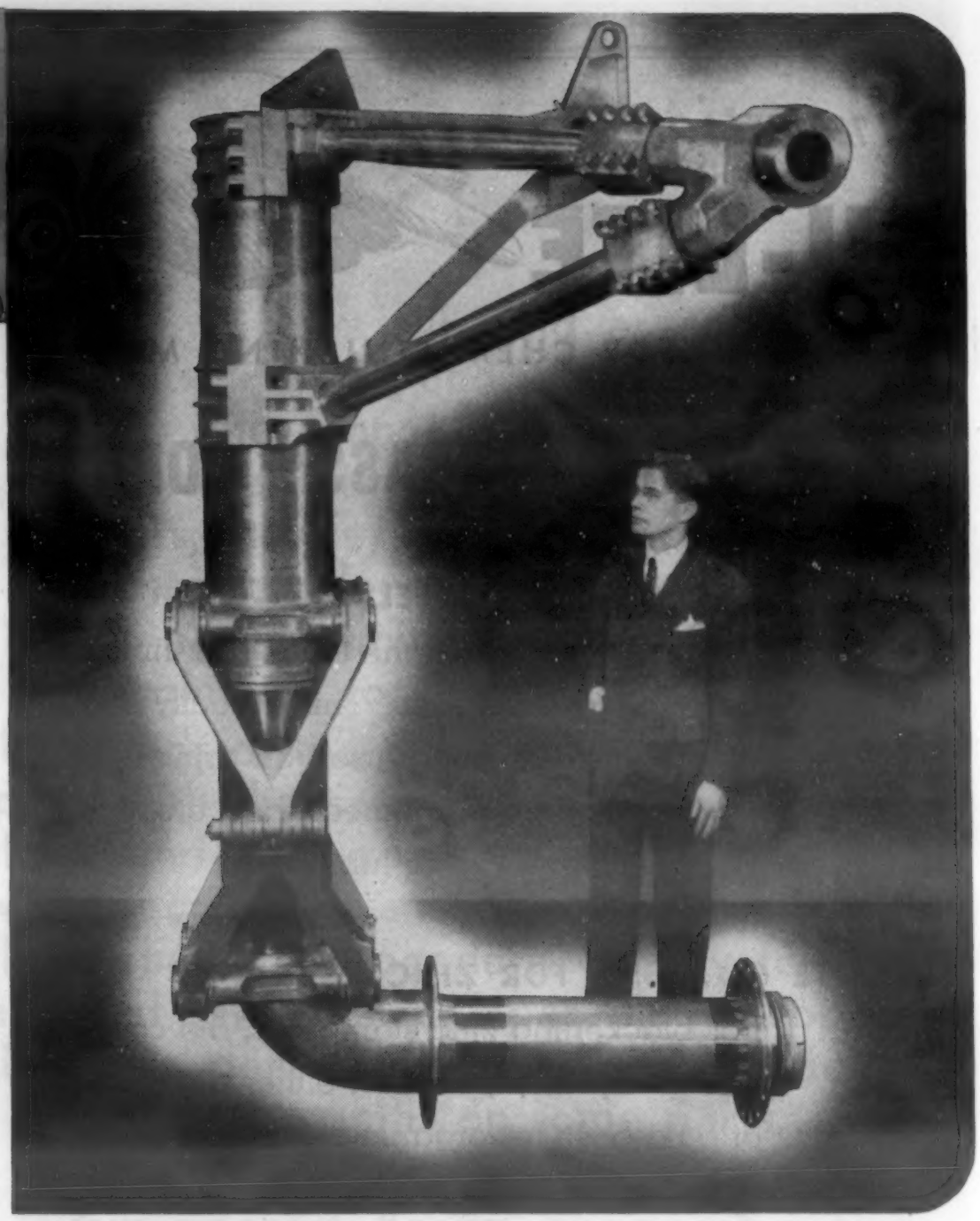

HUPPERT SERIES 16 FURNACE

The furnace body is ruggedly constructed of 14 gage steel, reinforced on all corners. Heating elements have totally enclosed contacts, and connecting wiring is brought through the back of the furnaces into a special compartment. They can be operated on 220-v. single- or three-phase line, and can be furnished up to 440 v., three-phase.

The Series 16 furnaces operate maximum at 1850 F. continuous and 1950 F., intermittent. Furnaces are complete, as delivered.

● A new electrode with a new coating for easy welding of aluminum sheet and castings is announced by *Eutectic Welding Alloys Co.*, 40 Worth St., New York. Known as Eutec Trode 2100, it provides for adding metal without completely preheating the casting. It is a high aluminum and low silicon composition that alloys to practically every type of aluminum. It is designed for salvage and reclamation of castings.





STEEL KNEES *for an* 80-TON WARBIRD

When an 80-ton battleship of the skies "sits down" hard on a concrete runway at 100 miles an hour, something must cushion the impact.

On the famous B-19 bomber, huge pneumatic-hydraulic aerols, like that above, help absorb landing shock—much as your knees helped soften the jolt of your boyhood back fence jumps.

The two mainlegs and nose strut weigh less than 4,000 pounds, but they were machined down from 53,000 pounds of rough forgings.

And there is an important reason for the use of Republic Electric Furnace Steel.

Costly man- and machine-hours were required to finish those close-fitting parts to exact tolerances. Had an imperfection in the steel caused rejection at final inspection, much labor and material would have been wasted.

But Republic Electric Furnace Steels provide extra insurance against such losses—because they are as CLEAN and SOUND as the most expert furnace practice and decades of experience can make them.

These fine steels are *consistently* UNIFORM—in physical, chemical, workability, hardenability values. They are homogeneous—free from variables that upset established practices. With them you can derive full benefits from mass production. And you can predetermine product qualities with exactness—because Republic Electric Furnace Steels are "targeted" by the precise control of electric furnace melting to hit the most rigid specification marks—accurately, repeatedly.

Republic's unequalled experience as the leader in this field of steel making and its increased capacity can help *YOU.* Ask us for further details.

REPUBLIC STEEL CORPORATION

Alloy Steel Division • Massillon, Ohio

GENERAL OFFICES • CLEVELAND 1, OHIO

Berger Manufacturing Division • Culvert Division
Niles Steel Products Division • Steel and Tubes Division
Union Drawn Steel Division • Truscon Steel Company
Export Department: Chrysler Building, New York 17, N.Y.

REPUBLIC

—Leader in the Production of

ELECTRIC FURNACE STEELS

"QUALITY" steels . . . alloy . . . stainless

Investigate

DU-LITE

PROCESSES FOR CHEMIFINISHING METALS

STEEL · ZINC · BRASS · COPPER

DU-LITE *Chemifinish* **FOR STEEL --**

A rust-resisting, tough, tenacious finish for blackening steel parts. This attractive, black oxide finish is widely used on arms, engine parts, tools and equipment; and on bearing surfaces as an aid to lubrication.

DU-LITE *Chemifinish* **FOR ZINC --**

For blackening zinc stampings, die castings, and zinc plated parts; for either a final finish or as a base for organic coatings.

DU-LITE *Chemifinish* **FOR BRASS AND COPPER --**

Used for blackening brass, copper, and copper plated parts; produces a uniform jet black. Oxidizing bath is stable; a thoroughly tested process for production use.

ALL DU-LITE *Chemifinishes*

have been exhaustively tested in laboratory and production. They are now accepted as standard by industry. Take advantage of DU-LITE'S service which has been of value to so many manufacturers. One of our field engineers will gladly call on request.

DU-LITE CHEMICAL CORP.
MIDDLETOWN, CONNECTICUT

Rocker Arm Spot Welder

A new rocker arm spot welder for production sheet metal work, incorporating features usually found only on larger machines, is sponsored by *Sciaky Bros.*, 4915 W. 67th St., Chicago 38. The upper arm has heavy-duty roller bearings at the fulcrum point. The pressure cylinder contains a rubber bumper to eliminate hammering.

Electronic controls and contactor are mounted in a hinged cabinet with convenient dials and switches. Current interruption may be either magnetic, or by ignitron tubes. Operation is fully automatic, with controls for welding heat, duration of current, cool period and off period.

Rated 30 k.v.a. at 50% duty cycle, it has capacity on clean mild steel of from two thicknesses of 0.016 in. up to and including 0.080 in.; on stainless steel, up to a maximum of 0.040 in. plus 0.040 in.

Speed on two thicknesses of 0.032 in. pickled mild steel is 180 spots per min. Electrode pressure at 24 in. throat depth is 1000 lb.

● What is claimed to be a very different approach to the delivery of infra-red heat is the Hy-Heat unit, sponsored by *Infra-Red Engineers & Designers,* 1633 E. 40th St., Cleveland. It is possible to place these units extremely close to the work, say ½ in. The rays strike diagonally instead of the usual 90°. Temperatures up to 500 F. are possible.

Hole Punching Equipment

Designed to punch holes in flat sheets, to provide maximum stripping action, and to be set up to punch unlimited patterns of holes on T-slotted plates and templates in stamping presses and on T-slotted plates and bed rails in press brakes, the *Wales-Strippit Corp.*, 345 Payne Ave., N. Tonawanda, N. Y., has brought out "BC" hole punching units.

Square sheared and curved sheets and long strips of flat material may be perforated in either short or long runs on a production basis. After a pattern has been run, the same group of units may be used in another pattern, thus eliminating "dead storage" of the units.

The units are made of punches, dies and stripping guide assemblies, held together by holders as independent, self-contained units. Various diameter holes up to 5/16 in. may be punched with the same unit by simply changing the punch, die and stripping guide assembly.

New and increased flexibility of uses is provided by these new Wales units.

● Four models of adjustable limit snap gages, known as midget type gages, have been added to the line of *George Scherr Co., Inc.*, 128 Lafayette St., New York 13. They are designed for checking and inspecting extremely small and delicate parts, handling work from 0.000 to 0.760 in.

You don't have to wait for dies— to get forgings like these!

To aid essential equipment and armament builders who cannot wait for the making of dies and the availability of drop hammers, we offer the facility of our large flat die hammer department plus the ingenuity of our hammersmiths and time-trained forging engineers, for making die forgings.

Hundreds of manufacturers have been supplied with thousands of forgings of varying shape and size, like those shown here, made with special tools and available dies but with flat die hammer procedure. Quality, tolerance and cost have been comparable to drop forgings, and delivery time has been reduced as much as six months on some parts.

If you need drop forgings now—contact your nearest Kropp engineering representative or send blueprints direct for quotation.

KROPP FORGE COMPANY

World's Largest Job Forging Shop

5301 W. Roosevelt Road, Chicago (50), Illinois

Engineering Representatives in Principal Cities

Makers of Drop, Upset and Hammer Forgings for Armament and Ordnance and Machinery of All Types

SERVING INDUSTRY 18 SINCE 31 OVER 100 YEARS — KROPP FORGE CO.

KROPP

ARMY E NAVY

Johnson steps up production and speeds deliveries. Now you can get Johnson Furnaces in One Week! Order your Johnson Furnaces today and start enjoying their famous time, gas, and space saving features.

No. 130-A Hi-Speed Steel Heat-Treating Furnace Firebox 7¾" x 13" x 16½".

No. 130-A to left has counterbalanced door opening upward. Tools may be inserted or withdrawn without fully opening door. 4-burner job shown, $295 F.O.B. Complete with motor and blower. 6-burner job, complete with motor and blower, $325 F.O.B.

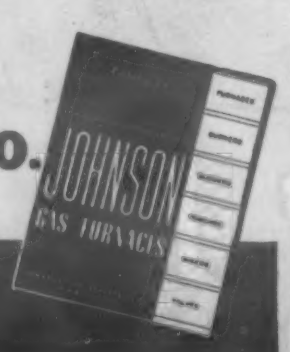
ALL PRICES F.O.B. FACTORY

No. 120 Hi-Speed Heat-Treating Furnace. Desirable for hardening dies, tools and punches. Comes equipped with G.E. motor and Johnson Blower. Heavily lined with refractory insulation. Carbofrax hearth. Easily regulated and adjusted. Produces 1500° F. in 5 minutes. Maximum temp. range 2400° F. Complete with motor and blower, $129.50 F.O.B. Factory.

No. 575 Pot-Hardening and Melting Furnace. Here's a Johnson unit that does a good job speedily and at low cost. Lid-lifting mechanism raises lid easily and locks it in UP position. Lined with 8" hi-temperature quality insulation. Pot size: 14" diameter x 20" deep. Scientific location of burners near top of combustion chamber insures longer pot life. Vent damper, regulates flow of exhaust gases. 3-section construction of top ring prevents cracking and distortion. Shipped complete with motor and blower, $400, F.O.B. Factory. Also available with 14 x 16 or 14 x 18 pot.

Parts available for ANY Johnson burner or furnace.
Offices at 120 LIBERTY STREET, NEW YORK 6, N. Y.
Bourse Building, PHILADELPHIA, PA.

JOHNSON GAS APPLIANCE CO.
621 E Ave., N. W., Cedar Rapids, Iowa



Free NEW JOHNSON CATALOG
WRITE ADDRESS ABOVE

Human Precision Gage

Makers of all sorts of precision gages might find themselves out of business if there were many such as Warren Black, 79 year old precision instruments worker with *Brown Instrument Co.*, Philadelphia.

He distinguishes by sight and touch alone the difference between 20,000ths, 22,000ths and 24,000ths of an in. in platinum wire diameters.

Inspectors have failed to find him wrong once in 20 years. He relates how 20 years ago he was refused employment because he was "too old."

In the accompanying photograph he is examining a patented Brown "butt weld" that he has just made.

● A new calculator for determining the welding preheating and interpass temperatures of steels has been introduced by *Lincoln Electric Co.*, Cleveland. It is 6¼ in. in diam., and consists of four movable sections of heavy cardboard stock. It is for those steels that have a higher carbon content and alloys requiring preheating.

Tempering Attachment for Spot-Welding

A new tempering attachment, for use with G-E synchronous spot-welding controls that incorporate the phase-shift method of heat control, is announced by *Industrial Control Div., General Electric Co.* It is particularly suitable in the spot-welding of air-hardenable steels, permitting tempering the weld while the work is in the machine, thus reducing hardness and increasing ductility.

The attachment consists of a heat-control and a time-control adjuster for tempering, and the relays that automatically transfer the additional heat-and-time adjustment from the spot-welding control with which the attachment is being used.

It is enclosed in a metal case for wall mounting. Calibrated adjustment dials are mounted on the hinged door, together with an On-Off switch for preventing the relays from being energized when ordinary spot or pulsation welding is being done.

WHEN YOU AND FORMICA ARE HONORABLY DISCHARGED

YOU'LL WANT THIS VETERAN IN YOUR PEACETIME PRODUCT

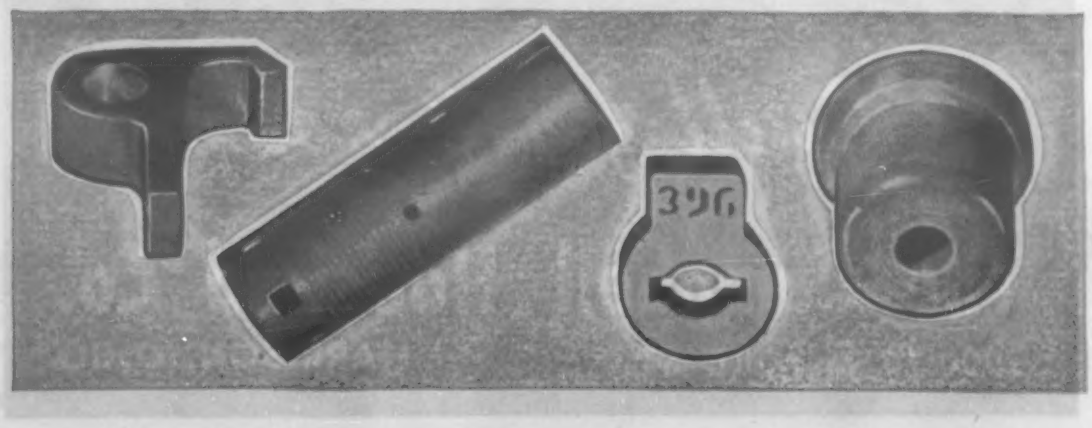
Formica laminated plastic is 30 years young, but a veteran with a long bright future before it helping you make better products for a better world. It passed the most rigid "physical" when it entered the armed services. It is serving in every branch on land, sea and in the air. It went through all the hells on all the fronts as parts of vehicles, planes, tanks, ships and communications equipment. It is coming back to you laden with stripes.

It has met the severest tests in the most gruelling combat to which men and materials have ever been subjected.

It is light for its great strength, non absorbent, acid resistant, and has good dielectric properties, machinability, and comes in many grades with special properties. Why not investigate its applicability to your post war product now.

"The Formica Story" is a moving picture in color showing the qualities of Formica, how it is made, how it is used. Available for meetings of engineers and executives.

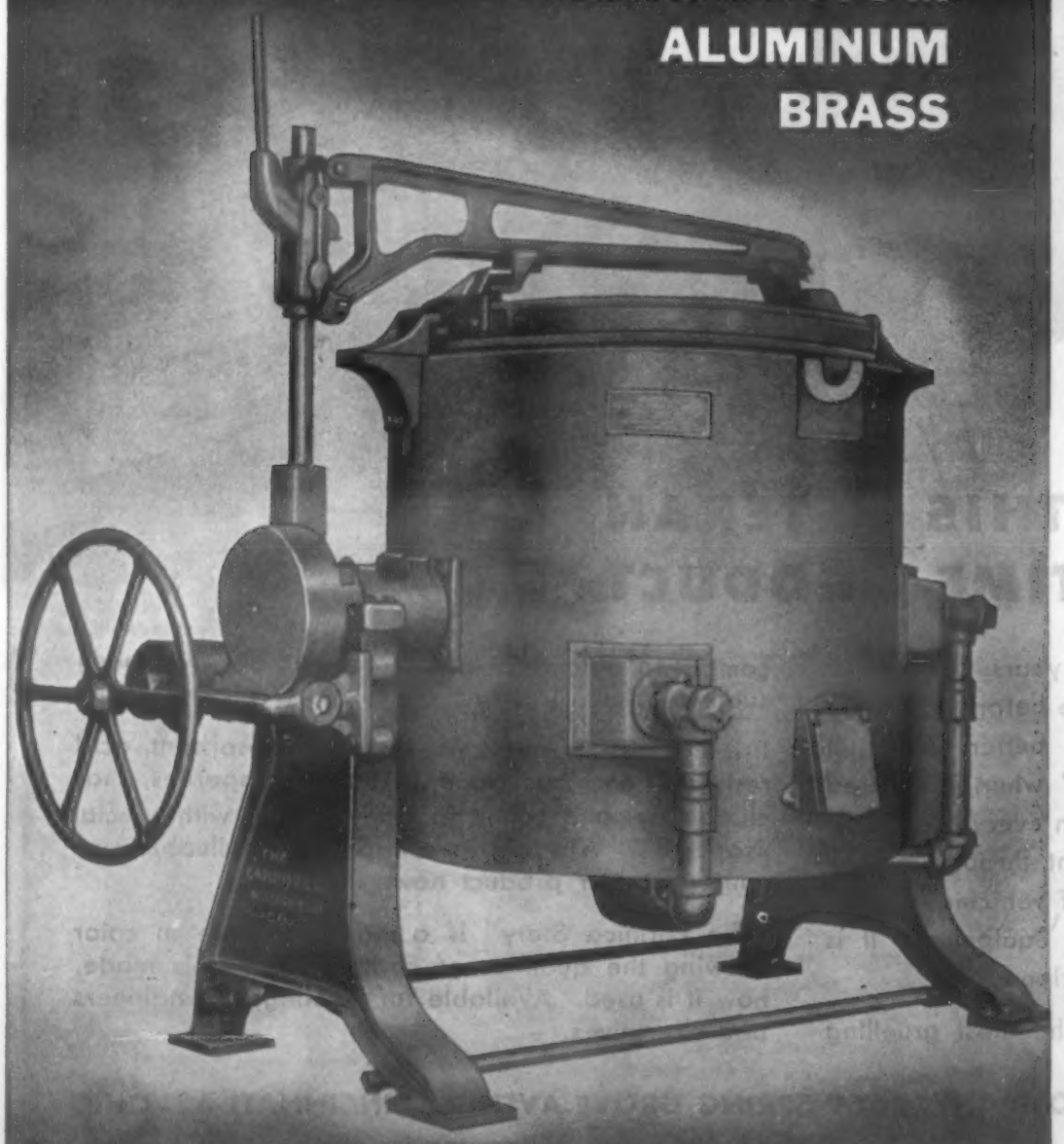
THE FORMICA INSULATION COMPANY, 4669 SPRING GROVE AVENUE, CINCINNATI 32, OHIO



HAUSFELD

A FURNACE FOR EVERY NON-FERROUS MELTING REQUIREMENT

MAGNESIUM
ALUMINUM
BRASS



Built for Service

The Campbell-Hausfeld Co.

200-220 MOORE ST. HARRISON, OHIO

Bending and Straightening Machines

A new line of bending and straightening machines, in six sizes and having capacities ranging from 50 to 400 tons for cold bending and straightening structural shapes and other metal forms, is announced by *Thomas Machine Mfg. Co.*, Pittsburgh 23.

Beams, channels, rails, shaftings, rounds, squares, forgings, structural sections, or any metal sections can be handled. Weighing from 3,800 to 55,000 lb., the machines can bend and straighten 5-in. to 24-in. beams.

The machine eliminates heating of beams or shapes. Since the work is performed cold, no furnace is required, and one man handles the operation.

A continuously running ram with one bending block, striking against the shape to be bent midway between two bearing blocks, represents the operating principle. The length of stroke of the ram is quickly adjustable by a convenient hand-wheel so located the operator has unobstructed view of his work.

● A new basic resin, called Duralon, is announced by the *United States Stoneware Co.*, Akron, Ohio, whose features are zero water absorption, insolubility in present-day solvents, stability in storage, and ease of workability. It is made from waste agricultural products, belonging to the group of "furanes." Among its many applications is its use as bonding agent in powdered metals.

Metal Powder Bronze Gun Bearing

This introduces Miss Merva Wilson, incidentally, ringed by a self-lubricating bronze gun bearing made from metal powders by *Amplex Div., Chrysler Corp.*, Detroit, which company has started production on parts made from metal powders approaching 100 lb. in weight.

Other adaptations in the powder field in this plant are new type alloys of blended powders, making of tool steel from iron waste, and self-lubricating iron bearings capable of carrying weight loads greater than 100,000 p.s.i.

IN PLANNING NEW EQUIPMENT FOR "POST-WAR" . . .

Consult KIRK AND BLUM *for Design and Preliminary Estimates*

To help with your pre-conversion planning, Kirk & Blum offers you the facilities and professional "know how" of 37 years of Sheet Metal Fabrication.

Our engineers will plan, design and give you preliminary estimates, without obligation on such sheet metal parts you feel may be needed. Samples will be furnished at cost if they can be readily produced by hand or with existing tools.

Sheet Metal Fabrication has long been an important part of our business. We specialize in parts and assemblies of sheet steel, alloy sheet and plate. We are completely equipped for all fabricating operations and assembling of completed products and assemblies.

For further details of the K & B pre-conversion service outlined above, write now, to The Kirk & Blum Manufacturing Co., 2852 Spring Grove Ave., Cincinnati 25, Ohio.

Our large and varied assortment of tools and dies may make it possible for you to produce needed articles with very little tool and die expenditure. We shall be glad to discuss this matter with you at any time—just drop us a line.

KIRK AND BLUM

It Takes the Best
TO MAKE THE BEST

Heat Treated Steel Shells

FOR THE heat treatment of heavy artillery, R-S Engineers have developed an automatic gas-fired installation of standard design which consists of a hardening furnace, quench unit and convection type draw furnace. The shells are pushed through the hardening furnace in parallel conyeying tubes, are quenched internally and externally, then leave the quench tank on a conveyor and go through the draw furnace on alloy chains.

Here is continuous operation that typifies not only the excellence of R-S Furnaces but the versatile, painstaking abilityof R-S Engineers.

FURNACE DIVISION
R-S PRODUCTS CORPORATION
4522 Germantown Avenue, Philadelphia 44, Penna.

R-S QUALITY PRODUCTS SINCE 1908

R-S Furnaces of Distinction

ANNEALING CONVECTION ROTARY HEARTH SALT BATH FORGING
CONTINUOUS CONVEYOR PLATE AND ANGLE HEATING METAL MELTING CAR HEARTH

★ ★ BUY WAR BONDS ★ ★

Glass Master Surface Plate

A new "Opti-Flat," a highly accurate, optically polished glass master surface plate, flat to an accuracy of 50 millionths of an inch, is offered by *George Scherr Co.*, 200 Lafayette St., New York 12.

The usual rule that measuring tools must be ten times more accurate than the work is much further carried out in the "Opti-Flat," which is accurate to one-half of one ten-thousandth of an in.

The flat is extremely resistant to abrasion, and is 2 in. thick for the 12-in. and 3 in. thick for the 16-in. size to prevent warpage and breakage. The "Opti-Flats" are inspected by optical flats by light interference methods, enabling checking for flatness within millionths of an in. They are annealed and free from strain.

● A pocket slide-type guide showing proper tip sizes, gas pressures, etc. for machine gas-cutting steel of various thicknesses with two gas-cutting tips, Airco 45 and 124, is offered free by writing *Air Reduction*, 60 E. 42nd St., New York 17, or any branch office. By setting the slide to one known factor, other specifications may be learned. The back lists hints for operators, such as setting up, piercing starting holes, making heavy cuts, etc.

One Coat White Enamel Finish

What is claimed to be the first commercially successful one coat white—one fired—direct to steel porcelain enamel, is announced by *Pemco Corp.*, Baltimore. Called "Mirac," it is the result of over 20 years of laboratory and field work.

The company says that it gives a white opaque finish with all the characteristics of the finest white cover coat and the adherence qualities of a good ground coat. It can be used in production in any well-equipped enameling plant; it requires no special bond or pickling equipment; it needs no special handling.

"Mirac" has excellent adherence, and can be fired at 1500 F. with a brilliant highly opaque finish.

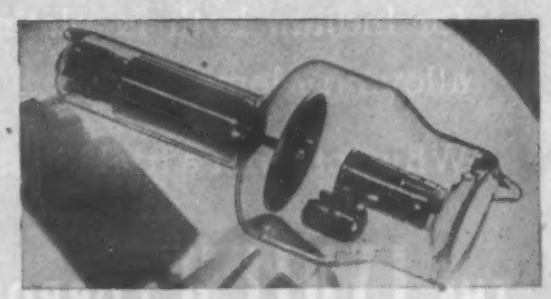
They came to Machlett for the answer

Some time ago a group of distinguished scientists and engineers designed, on paper, a most remarkable new instrument that could be invaluable in a certain war activity. But when the final calculations had been completed, it was realized that the device required a tube that not only had never been made, but perhaps never could be in adequate numbers.

An impressive delegation of these gentlemen visited the Machlett Laboratories, and explained the situation. Would we study the matter? "If you conclude the problem cannot be solved," they said in substance, "we shall have to revise our design and be satisfied with only a fraction of the desired performance, because we know that if a tube is too difficult for you, certainly no one in the world can make it."

This is the kind of challenge Machlett likes. Today that tube is produced in quantity and is serving our country at war.

Some day the full story of that extraordinary achievement can be told. Now it can only be referred to in general terms, as an example of the skill that makes Machlett the world's largest manufacturer of X-ray tubes for medical, dental and industrial uses. Today, Machlett, in addition, makes various electronic tubes for special purposes in those fields and in radio. Machlett does not make apparatus, but tubes only . . . Machlett Laboratories, Inc., Springdale, Connecticut.



Machlett x-ray tube with rotating anode. 100 kilovolts; 50 kilowatts.

MACHLETT

X RAY TUBES SINCE 1898

TODAY THEIR LARGEST MAKER

INDIUM

Prepared Balanced Solutions for the Plating Industry!

DEX-SOL-IN
FAM-SUL-IN
FLO-BOR-IN
FLO-SIL-IN
CY-AN-IN

These are coined names with each syllable identifying a constituent. All end with IN – the symbol for Indium.

These Indium solutions for the plating shop are exceptionally pure. They're prepared in our own plant under the supervision of our technicians... the very ones who have developed so many uses for Indium both in plating solutions and as an alloying element.

Why not order a trial lot, sufficient for a good test?

THE INDIUM CORPORATION OF AMERICA
UTICA, N. Y.

ARMY E NAVY

NEW YORK OFFICE **60 EAST 42nd STREET**

THE INDIUM CORPORATION OF AMERICA Platicoat 49

7-IC-1

Carbide Insert Thread Milling Cutters

A new line of carbide insert thread milling cutters is announced by *Plan-O-Mill Corp.*, 1511 E. Eight Mile Road, Hazel Park, Mich. They are available in National, Whitworth, Acme, V, and special forms, ground or unground, with straight or spiral flutes, with or without provision for the Higbee cut.

These carbide insert cutters are faster cutting, produce exceptional finish and accuracy, and experience longer tool life.

● Spun acetate grommets are being used successfully in aircraft, hydraulic controls, small motors and lamps, states the maker, *Precision Paper Tube Co.*, 2035 W. Charleston St., Chicago 47. They are made of acetate film, spirally wound and laminated. They provide good insulating properties and non-shatterable toughness. Other qualities are light weight, resistance to oil, moisture, etc.

100-Lb. Tungsten Carbide Die

Indicative of the expanding use of carbides in larger sizes, particularly where wear resistance is important, a huge sheet metal die, manufactured at *Carboloy Co.'s* Detroit factory, contains enough cemented

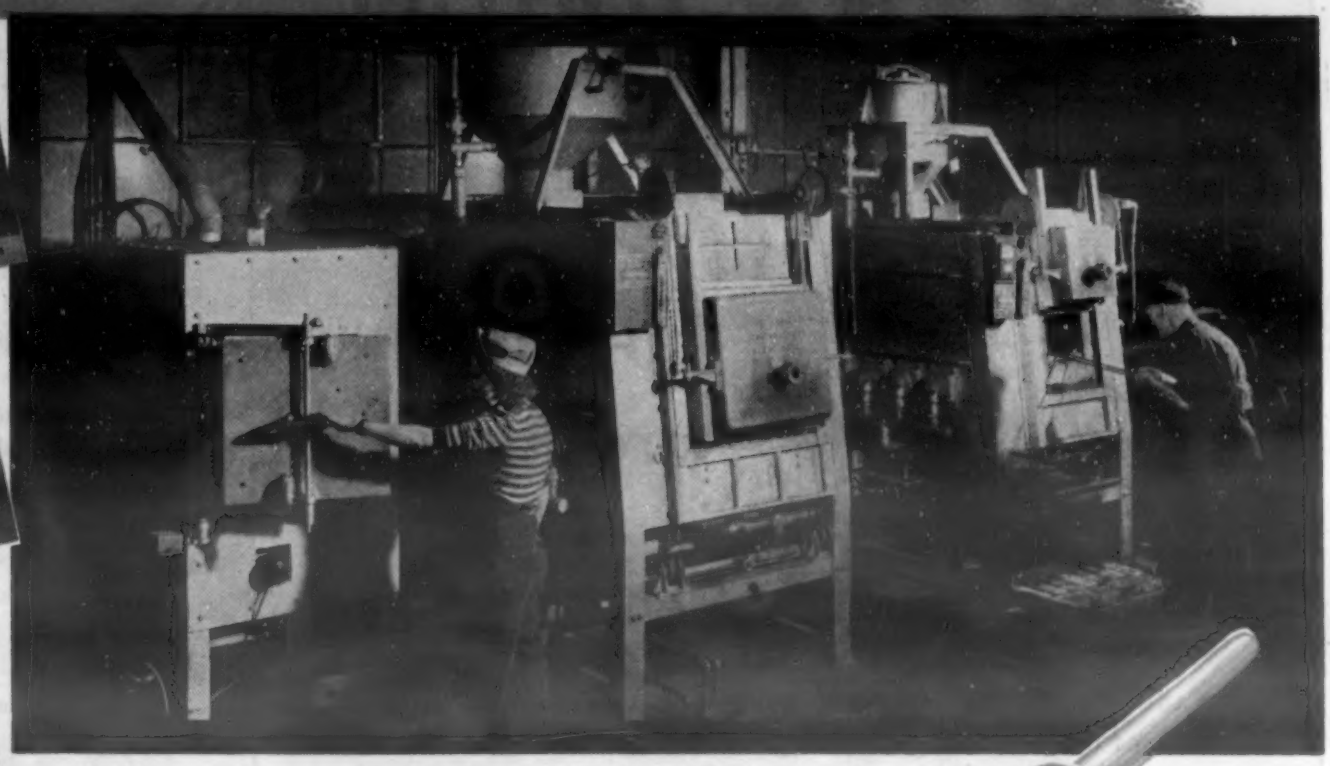
carbide to make several thousand average sized tips for cutting tools!

The carbide nib weighs over 100 lb. Used for more economical deep drawing of sheet steel compressed gas storage tanks, the completed hard carbide die nib, which is shrink fitted into a steel casing, has an I.D. of approximately 9½ in. and an O.D. of 13 in.

● The cross-bow, storied weapon of medieval times, is used by *Westinghouse* in building electron microscopes. Fashioned from tough, flexible steel and mounted on a wooden stock, it shoots an arrow that draws out quartz filaments so fine that it would take 60 to equal a human hair. The filaments are used to calibrate the magnifying power of the microscope.

TOOL ROOM FURNACE REQUIREMENTS

should govern selection



● **A spanner wrench won't tighten pipe—it wasn't designed for that purpose. Furnaces, like tools, are best suited for the operations for which they were designed.**

One group of furnaces will not meet the heat treating requirements of every tool room. The tools—the steels—the uses all differ; therefore, the best for one is not satisfactory for all.

Don't accept a pre-selected group of furnaces—pick the combination that best meets the requirements. Surface Combustion offers over thirty types of Standard Rated Furnaces to select from and have engineers available in principal cities to assist in analyzing the needs and selecting the equipment.

Ask for these Illustrated Bulletins:

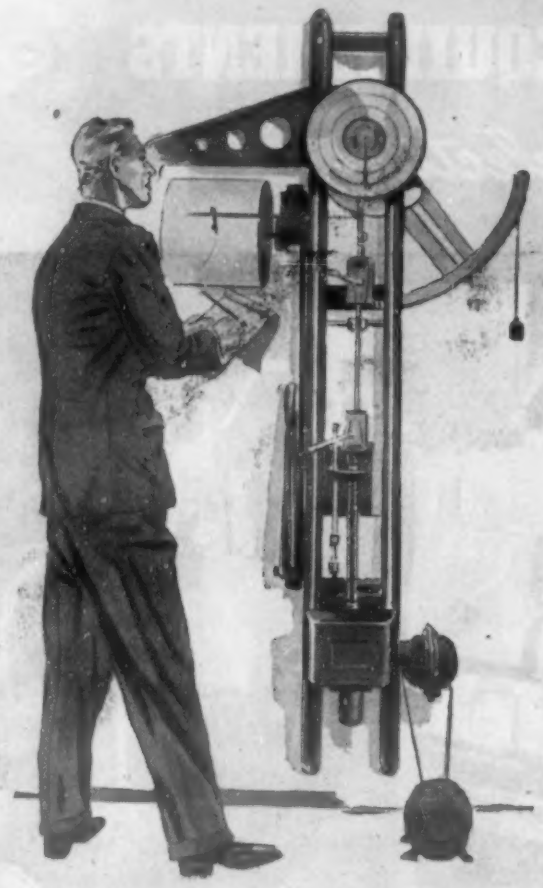
I-43, Standard Rated Design Features
OG-43, Oven Furnaces
AG-43, Atmosphere Furnaces
PG-43, Pot Furnaces
CG-43, Convection Furnaces

The Heat Treater's Helping Hand

'Surface'

SURFACE COMBUSTION • TOLEDO 1, OHIO

Standard and Special Industrial Furnace Equipment For:
Forging, Normalizing, Annealing, Hardening, Drawing, Carburizing, Nitriding and Heating. Special Atmosphere Generators. *Write for Bulletins.*

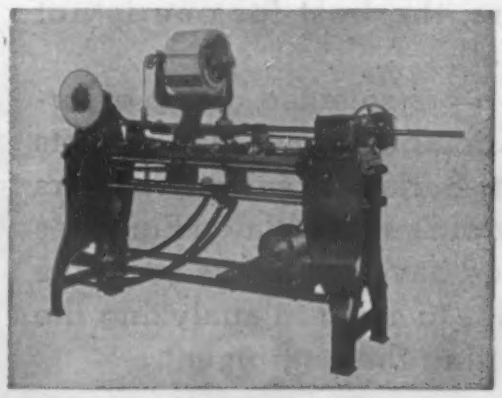


*SCOTT TESTERS

promote maximum production

An adequate testing procedure gives assurance and facility to the processes of research, purchasing, manufacture, and final check. * Scott Testers are especially helpful in these connections, first because they produce results on a World-Standard basis; second, because they have numerous features contributing speed of testing and ease of observing results; third, because their readings are presented in picturized form on graphic charts convenient for comparison and for reference filing.

We make more than 60 models for tensile, hysteresis, flexing, twist, compression cutting of rubber covering, etc., etc.



Model Q-7 Scott Tester. Heavy duty tensile tester for wire, with capacity up to 2,000 lbs.

Request Circulars

HENRY L. SCOTT CO.

65 Blackstone St. **SCOTT TESTERS** Providence, R. I.

* Registered Trademark

Scott Testers — Standard of the World

Gear Finishing Machines

An improved line of its "860" series of rotary crossed-axis gear finishing machines is currently in production at *Michigan Tool Co.*, 7171 E. McNichols Rd., Detroit 12.

The line comprises four basic models, the 860 for shaving narrow face and shoulder gears by the "underpass" method; the 860-B for shaving wider-faced gears by the "transverse" shaving method; the 860-A in which both the "underpass" and "transverse" shaving methods are provided; and the 860-C for shaving of internal gears.

The first three models come in three sizes, for shaving gears with a maximum O.D. of 8, 12 and 18 in., respectively.

Among the improvements made in the machines are the use of cone-drive gearing for maximum drive-smoothness and quieter operation; ability to obtain shaved gears with a finish superior to ground gears; provision of increased power to form a reserve for special jobs; improved facilities for curve-shaving; greater flexibility in application of the same machine to different jobs; reduced maintenance through a "one-shot" automatic lubricating system, etc.

Emergency Plug Gage Blank Sets

A set of 36 cylindrical plug gage blanks in steps of 1/16 in., with handles, will permit any shop to produce any size plug gage from 0.029 in. to 1.000 in. in just a few minute's work on a cylindrical grinding machine.

Called the "New Atlantic Emergency Set," it is announced by *George Scherr Co., Inc.*, 200 Lafayette St., New York 12.

The blanks are oil hardened throughout, shank finish ground and centers on both ends are lapped. It is necessary only to grind the blanks to produce a commercial finish gage. Where closer tolerances are involved, the gages are then lapped.

(*Continued on page 222*)

Quicker Deliveries of Stainless Steel

CAN NOW BE MADE

Rustless concentrates on Stainless Steel billets, bars and wire. Deliveries are better than they have been for almost four years.

May we quote on your requirements?

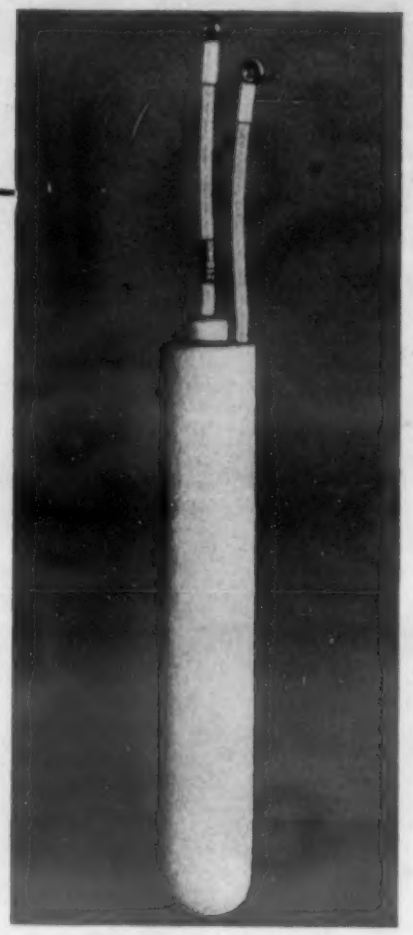
RUSTLESS

Producing STAINLESS STEEL *Exclusively*

RUSTLESS IRON AND STEEL CORPORATION BALTIMORE 13, MD.

SALES OFFICES: BUFFALO • CHICAGO • CINCINNATI • CLEVELAND • DETROIT • LOS ANGELES
NEW YORK • PHILADELPHIA • PITTSBURGH • ST. LOUIS • DISTRIBUTORS IN PRINCIPAL CITIES

For Heating Acid Solutions



VITREOSIL
IMMERSION HEATERS
offer
3 Outstanding Advantages!

Electric immersion heaters are admirable for heating acid solutions, but the envelope for the heating unit must be acid-resistant, a good electrical insulator, and unaffected by thermal shock. Vitreosil (vitreous silica) possesses all these properties.

1 Chemical Inertness With the exception of fluorine and hydrofluoric and phosphoric acids, Vitreosil is unaffected by halogens and acids regardless of temperature or concentration.

2 Electrical Insulating Qualities Vitreosil surpasses porcelain, mica, glass and similar materials in that it maintains its insulating value despite extreme temperature conditions.

3 Low Expansion Vitreosil may be exposed to rapid and extreme thermal shock without danger of breakage because its expansion is the least of any commercial ceramic.

Vitreosil Electric Immersion Heaters are available in lengths ranging from 10 to 30 inches with k.w. ratings of .25 to 5.0. Write us for explicit data and quotations.

VITREOSIL CONTAINERS FOR HEATING ACIDS

Round Bottom Evaporating Dishes
Cylindrical Pots
Rectangular Tanks
Four-sided Trays
Retorts or Dissolving Jars

VITREOUS SILICA — VITREOSIL — REG'D TRADE MARK

THE THERMAL SYNDICATE, LTD.
12 EAST 46th STREET, NEW YORK 17, N.Y.

Spot Welding Timer

A new precise welding timer with heat control for timing intervals of one-half cycle or less, suitable for welding small objects of high conductivity such as aluminum and copper, is introduced by *Westinghouse Electric & Mfg. Co.,* East Pittsburgh, Pa.

The welding current is made to start at the same point on the voltage wave for every operation. It is designed for such items as radio tube parts and sockets, pigtail resistors to terminal lugs, watch and instrument parts, contact tips on electrical relays, etc.

The timer is furnished as a separate control for existing small bench welders, and in combination with a small welding transformer.

Only one central tube is used, this thyratron serving the dual purpose of rectifying alternating current to charge a firing capacitor and firing the small ignitron power tube. Heat control is accomplished by a phase shift method, the adjustment dial being mounted on the cabinet door.

The timer is rated at 230 to 460 volts, 50 to 60 cycles.

● A new wet grinder has a perfectly true, concentric running, 10-in. Berea-quarried sandstone wheel, accurately centered on its arbor. Put out by *Boice-Crane Co.,* 962 Central Ave., Toledo, Ohio, it grinds a straight bevel from heel to edge without weakening tool temper. It is designed for grinding speed of 120 r.p.m.; it throws no water, and may be belted to a 1750 r.p.m. motor.

Precision Measuring of External Diameters

Precision external indicating gages, using the flow of air as the measuring medium and operating in conjunction with the Metricator instrument, are sponsored by *Metrical Laboratories, Inc.,* 417 Detroit St., Ann Arbor, Mich.

The gages can be made in either the indicating ring or indicating snap gage type, depending on the size of the external diameter to be measured. Size variations as small as 0.000025 in. can be readily detected. In fact, the amplification can be sufficiently increased so that parts can be sorted into groups of 0.000010 in. size difference without any effort on the part of the operator.

Indicating rings are of particular value with indicating plug gages applied to mating parts for selective fits. The total range covered by these gages at an amplification of approximately 4000:1 is 0.002 in.

The instrument functions well on parts ground in a centerless grinder, it being possible to obtain an accurate indication of the extent of a "three-cornered" out-of-round condition.

(Continued on page 225)

Welding Rod for Zinc Die Castings

Zinc-base die castings, that are normally difficult to repair, can now be easily and effectively reclaimed with the improved gas welding rod, 195, it is claimed by the *Eutectic Welding Alloys Co.*, 40 Worth St., New York 13.

It has a lower melting point and a still lower bonding temperature than the original alloy, which makes it easier to apply without danger of damaging the parent metal.

The improved rod is easier to build up with, has greater tensile strength, and matches the hardness of the die castings. An example was a zinc-base fuel pump die casting that had the whole top section broken off.

Attempts to build up the part with ordinary rods had been futile, for at the point at which the alloy had to be applied there was a hole 3/8 to ½ in. in diameter. This hole had to be bridged without the help of a backup material inside the assembly.

In using the new rod, 195, the break was "V'd" out to a 90° angle and the section was cleaned. The entire casting was preheated with an acetylene excess flame to 700 F. Autochemic Eutector flux 195 was sprinkled over the metal and, when melted, the rod was placed in front of the torch.

The lug was built up to its normal height in less than 5 min. and only 1 in. of ¼-in. thick rod was used. Hundreds of similar defective castings are now being saved.

● A new Alkyl aromatic solvent concentrate that inhibits rusting of parts cleaned, is non-inflammable and non-combustible, is announced by the *Curran Corp.*, Dowling Bldg., Malden, Mass. It has no low volatiles and forms sparkling clear solutions with water, completely stable at elevated temperatures. The same company makes "Gunk," a self-emulsifying degreasing solvent, previously announced in these columns.

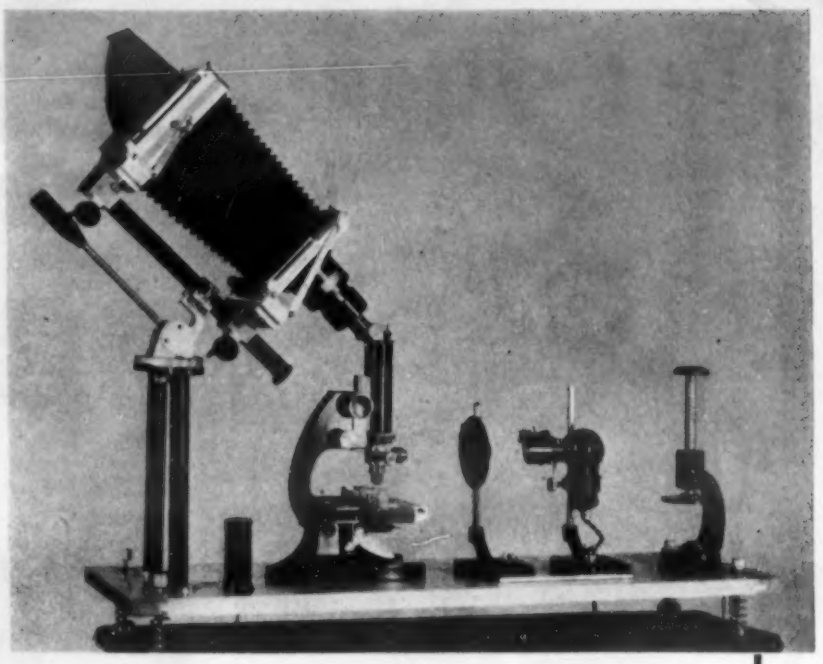
Plastic Linings for Acid Tanks

A new use of plastic as the lining for 28,000 gal. tanks holding chromic and sulphuric acid anodizing solutions in the treatment of aluminum alloy aircraft parts is announced by *E. I. duPont de Nemours & Co., Inc.*, Wilmington 98, Del. The resistance of "Lucite" methyl methacrylate resin to attack by acids is the basis for its use.

Sheets of this "Lucite" are now used in the huge tanks in which aluminum parts are given surface oxidizing treatment at the Curtis-Wright Corp. plant, Columbus, Ohio. The lining is not affected by sudden temperature changes nor by the 15% chromic acid solution.

It is less expensive, lighter, less subject to breakage, and easier and safer to handle than the material that the plastic replaced.

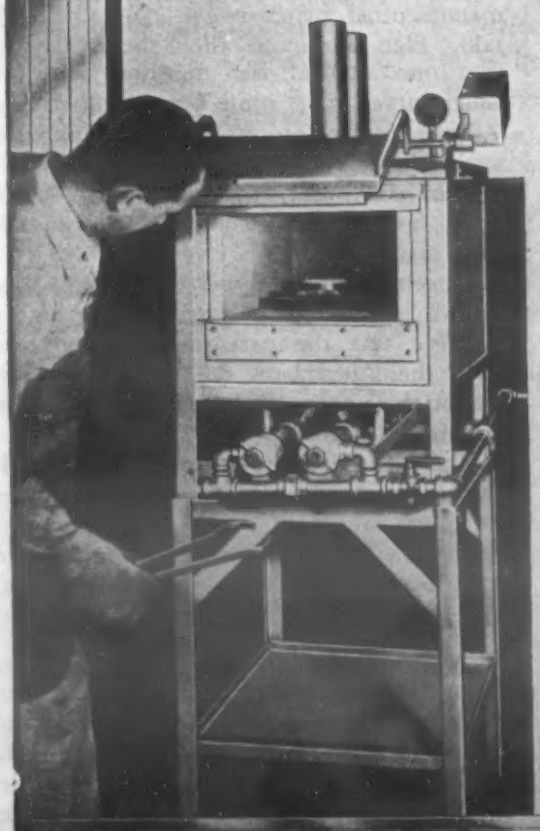
METALLOGRAPHIC MICROSCOPES



for VISUAL WORK
and PHOTO MICROGRAPHY
BRINNELL and SHOP MICROSCOPES
IMMEDIATE DELIVERY

GAMMA INSTRUMENT CO., INC.
95 Madison Avenue, New York 16, N. Y.

Baker Gas Furnaces
TEMPERATURES UP TO 2400° F. WITHOUT A BLOWER



BAKER Blowerless Gas Furnaces are very low in gas consumption, noiseless in operation, reach the required temperature rapidly and are equipped with thermocouple and accurate pyrometer. The research departments of some of the largest corporations have contributed to making their high efficiency possible.

There are 9 standard stock models ranging in size from No. 1 (Bench type), which is 6" x 8" x 5½", to No. 24, which is 12" x 20" x 8" as illustrated. All provide uniform, controlled heat up to 1900° F.

Model No. 5, 6" x 12" x 5", is built especially for treating high speed steel. Gives uniform, controlled temperatures up to 2400° F.

We stock one Hydrogen Atmosphere furnace, No. 12, with a closed muffle 8½" x 15" x 2½" high.

Special size furnaces built to your order. Write for descriptive folder and prices.

BAKER & CO., INC.
113 Astor St., Newark, N. J.

In Castings

must go hand in hand!

For only thru' quality controls can quantity castings be successful. And quality depends on *good melting practice.* The quality of your castings is insured with the use of FOSECO products. Make the test in *your* plant.

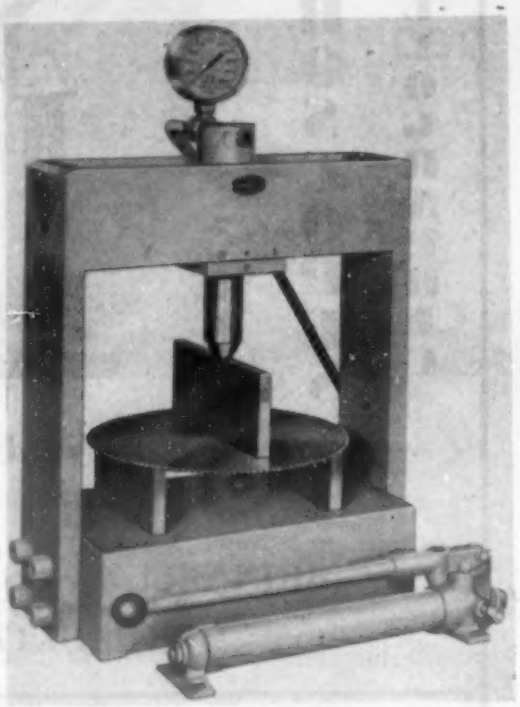
FOUNDRY SERVICES, *INC.*

280 Madison Avenue
New York 16, N. Y.

Laboratory Press

A new laboratory press has been added to its line by *Anderson Bros. Mfg. Co.,* 1907 Kishwaukee St., Rockford, Ill. It has a total capacity of 20 tons and has a stroke of 5 in.

The table is 12 by 20 in., and is accurately machined. A hydraulic hand pump furnishes power.



The press can also be used for many production straightening jobs, such as large sprockets, gears, plates, etc. A large sprocket is shown in place on the machine in the photograph. The weight of the press is 400 lb.

Forming Rolls for Aluminum Aircraft Parts

A new design of forming roll, capable of forming leading edge skins or fuselage skins to desired contour, automatically, in one pass through the machine, is being manufactured by *Farnham Mfg. Co.,* Buffalo. Flat aluminum alloy sheets are fed into one side of the machine, and finished curved parts come out the other side.

The former process of changing dial settings and reversing the rolls several times is eliminated, and production is six to ten times faster. Unskilled workmen can operate satisfactorily.

Movement of the upper roll is controlled by two templates, one on each side of the machine. As the part feeds through the rolls, these templates raise or lower each end of the upper roll, as required, to form the proper contour.

Hydraulic pressure keeps template followers against the templates and facilitates the quick raising of the upper roll for inserting the sheet to be formed. Adjustable stops locate sheets in their proper position.

● A chemical solution for hardening gears, pinions, axles, shafting, etc., called "Super Temp," is introduced by *Steeltem Chemical Co.,* 51 E. 42nd St., New York 17. Though not designed for shock tools, it is suitable for high-speed cutting tools that operate with a rotary or uniform motion.

Abrasive Belt Grinder

A new 10-in. "Wet-n-Dri" abrasive belt grinder that performs faster and better on jobs now being done on shapers, milling machines, surface grinders, disc grinders, etc., is announced by *Hammond Machinery Builders, Inc.,* 1646 Douglas Ave., Kalamazoo 54, Mich.

Easily within the range of work possible are deburring, descaling, chamfering, beveling, and the finishing of pads, bosses and thin sections of castings, forgings, stampings, etc.

The abrasive belt can operate to the edge of the belt backing-plate, where clearance is provided for getting into corners. The oscillating table has a micrometer stop graduated in 0.001 in. for accurately controlling depth of grind, and has three "T" slots for attaching fixtures.

A single handle both feeds and oscillates, the latter providing faster cutting and promoting uniform wear on belt and belt backing-plate.

New Electrode Holder

A new electrode holder, molded of a high heat resistant plastic to insure full insulation and to eliminate arcing due to slag, moisture or contact with grounded surfaces, is announced by the *Allison Tool & Engineering Co.,* 4031 Whittier Blvd., Los Angeles 23.

It is made in two identical models. One, A, is a 19 oz. unit to handle heavy 300 to 500 amp. work; B is a 6¼-oz. holder for lighter 200-amp. jobs. It incorporates only three main parts—the handle, cable connector and the tip.

Designed for either mechanical or solder cable connections, it features quick change and permits burning of electrodes to within ½ in. of the holder tip. Left hand threading in the tip and handle connection securely grips the electrodes and prevents their slipping.

The National War Fund

Readers of METALS AND ALLOYS are asked to set aside funds that will be earmarked for contribution to the *National War Fund,* 46 Cedar St., New York 5, during the forthcoming fall campaign in October and November. The Fund is the sole financing organization for 19 war-related agencies serving our fighting men and our allies—such as the U.S.O., United Seamen's Service, War Prisoners' Aid, United China Relief, Russian War Relief and others.

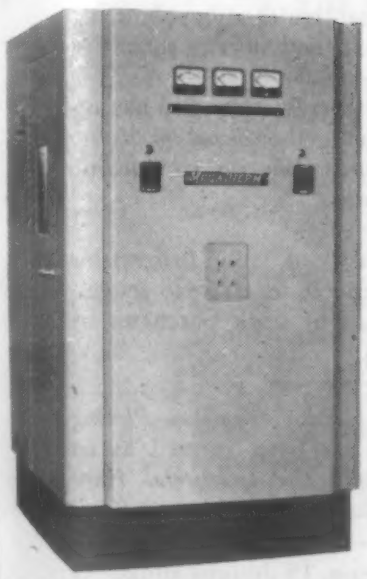
The National War Fund is served by 4,000,000 volunteer workers in cities, towns and hamlets throughout the Nation. Working through 48 state organizations in direct contact with the national office, the yearly appeal is carried on by 10,000 committees.

So, readers, keep receptive to the coming fall appeal!

Hard-to-Reach Sections

Brazed in Seconds with MEGATHERM Heat

... a simple, speedy operation with new High Frequency Technique



Federal Industrial Power Tubes, built with the ultimate of care and workmanship, give power and performance to Megatherm and other industrial heating equipment.

PROBLEM: **How to braze an inner cup to the outer shell of an aircraft part . . . in *seconds*?**

ANSWER: **Megatherm High Frequency Heat — with definite control of heat location by means of a simple director coil!**

By the use of similar coil units, precision localized heat applications can be made on a wide variety of difficult jobs.

Megatherm accomplishes this and other brazing or silver soldering operations on small complicated parts, with precision results — at high speed, under ordinary atmospheric conditions and without warpage, burning or surface contamination.

Low power requirements and overall economy make Megatherm High Frequency brazing and soldering an important production tool.

For technical data on Megatherm's new and fundamental advantages for brazing, soldering, annealing and surface hardening write Department N.

-MEGATHERM-

Federal Telephone and Radio Corporation

INDUSTRIAL ELECTRONICS DIVISION

AN IT&T ASSOCIATE

Newark 1, N. J.

Toss that
EXTRA TOUGH
DIE PROBLEM
In OUR lap

Using Strenes Metal, we'll cast your dies to shape, (usually to 1/16") and save you around 50% to 75% on machinery time. What's more you'll put to work a die that will stand up—draw and form far more stampings than you probably believe possible. Deep draw runs of 1,000,000 and more parts a matter of record.

You'll be using a die that will require redressing far less frequently than dies of ordinary metal. Sounds good, but, hard to believe, you say! Perhaps. But our suggestion stands "Toss us that tough one" and pay for it when Strenes makes good as claimed—otherwise there will be no charge.

THE ADVANCE FOUNDRY CO.
100 Parnell St., Dayton 3, O.

Refrigerators
Stoves
★ Automobiles
★ Trucks
★ Tractors
Metallic Vaults
Metallic Caskets
Farm Equipment
Fans, Blowers
Bicycles, etc.
★ In automotive field in general use for drawing and forming car bodies, hoods, fenders, head lights, radiator shells.

Strenes
METAL
DRAWING AND
FORMING DIES

News of Men, Societies, Meetings and Companies

Plants and Slants

Roy A. Kropp, president, *Kropp Forge Co.*, Chicago, believes that promotion of smiles is essential to war work and morale. From his advertising agency he ordered a series of cards, each featured with an illustration of a cheery smile. The cards were circulated among several thousand customers and associates. The result was infectious. Typical is a card showing a baby smiling and showing his first two teeth. The verse:

"When a bit of sunshine hits ye
After passing of a cloud,
When a fit of laughter gits ye
And ye'r spine is feelin' proud,
Don't forget to up and fling it
At a soul that's feelin' blue,
For the minit that ye sling it
It's a boomerang to you."
—Capt. Jack Crawford

A new refrigerator that would hold enough beer for an army—but would crack the bottles at its temperature of minus 70 F. —has been built by the *York Corp.*, York, Pa., and is installed at Wright Field, Ohio. The 80-ft. long cold chamber is large enough to put an entire fuel servicing truck "on ice." It is designed to test the ability of Air Forces equipment to take the punishment of arctic weather. The refrigerator is 25 ft. high and 25 ft. wide and has two compartments so that two tests may be carried on simultaneously.

A thorough program for re-employment of discharged servicemen has been inaugurated by the East Pittsburgh plant of the *Westinghouse Electric & Mfg. Co.* Of 5600 employees who entered the armed services, 455 have already returned to work. Key point in the program is complete analysis of every job in the plant to determine what can be filled by handicapped veterans. A "job card" quickly tells whether the veteran will "fit." Veterans are given service credit for time in the armed forces; they are given aid in medical rehabilitation; they are helped with "red tape" in civilian life; and they are guided in several ways to adjust themselves to civilian employment.

The *Rust Furnace Co.*, Pittsburgh, has recently received several export orders. One is from Russia for three continuous bloom heating furnaces for a rail and structural mill. Rated furnace capacities are 60 tons per hr. Another contract, for Brazil, is for an additional battery of two-hole, modern regenerative soaking pits for use with lean fuel.

The *Western Electric Co.* is taking possession of the plant at Scranton, Pa. of the *Defense Plant Corp.* It will transfer a portion of its wire and wire products operations from its works in Baltimore to Scranton, which becomes a "satellite" of the Baltimore works. At the Scranton plant, aircraft piston rings were formerly made. *Western Electric* is now the largest manufacturers of electronic and communications equipment for our armed forces.

Revere Copper & Brass, Inc. is now operating one of the largest magnesium extrusion plants in the country at Halethorpe, Baltimore, costing $7,000,000. Principal products are sheets, strips, tubes, rods and various shapes. It is interesting that a firm that has one of the oldest names in the copper industry should become prominent in the field of this newest commercial metal.

The permanent mold foundry of the *Monarch Aluminum Mfg. Co.*, Cleveland, is being modernized at a cost of $145,000, authorized by D.P.C. New furnaces, additional controls, a continuous conveyor belt for handling and inspection of castings, additions to chemical and physical laboratories and a new ventilating system will be installed.

The *A. M. Byers Co.*, Pittsburgh, which only began alloy steel production at the start of the war, now ranks among the largest producers of alloy steels in the Pittsburgh area. It has an annual capacity of over 100,000 tons, and plans to continue such production after the war, complementing its wrought iron output.

Westinghouse's Andrew Mitchell, tool supervisor, metal stamping department, East Pittsburgh, has received the "Safety Ace" award, voted by the National Safety Council. The award is because of his "leadership among plant safety men, his work in educating new workers, and the development of devices to reduce hazards on machines."

The *Lukens Steel Co.* has bought properties of the *Bethlehem Steel Co.*, located at Coatesville, Pa., embracing 35 acres and including a charcoal boiler tube plant, an office building, tracks and storage yard.

The *Timken Roller Bearing Co.* has organized a subsidiary, the *Timken Roller Bearing Co. of South America*, to function actively after the war.

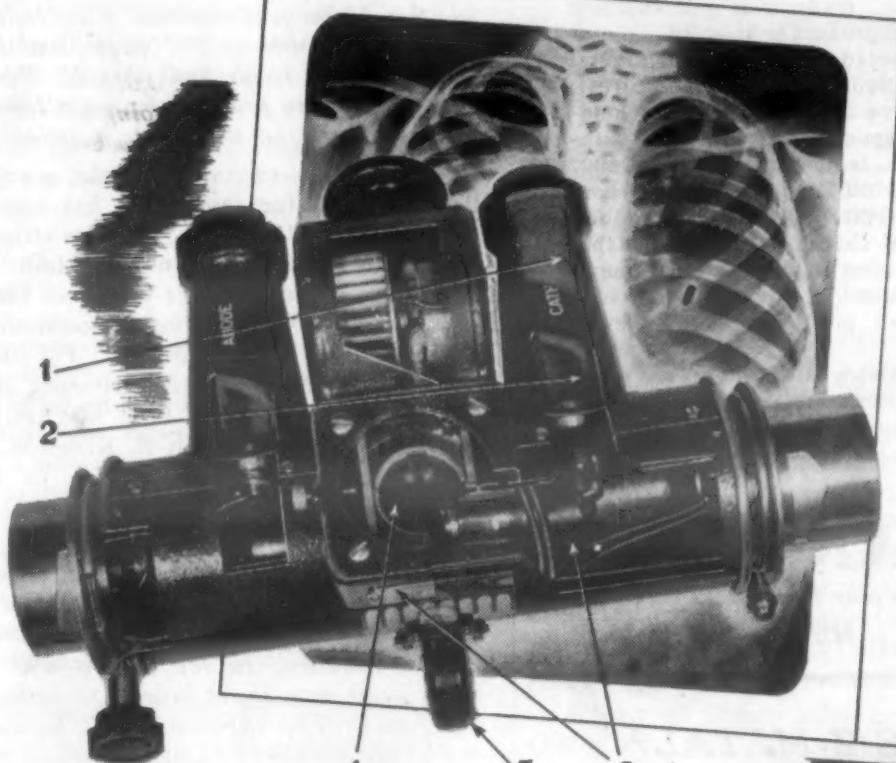
Partial ownership of the *Progressive Welder Co.* has been transferred to its employees as the result of stock purchases by individual workers.

The *Industrial Hard Chromium Plating Equipment Corp.* has been formed as an associate company of the *Industrial Hard Chromium Co.*, Newark, N. J.

Whimsical insignia, 18 designs altogether and one for each plant department, have been designed by a plant artist of the Ohio Crankshaft Co., Cleveland. They are patterned somewhat after those marking fighting units of the Army Air Forces. Done in full color and in oils, the Cleveland Museum of Art requested them for a ten-day exhibit. Friendly interdepartment spirit is fostered by them. They prove good morale adjuncts.

BAKELITE

TRADE-MARK



1—BAKELITE *Low-Loss* Phenolic provides exceptional electrical insulation for high-voltage lead-in socket.

2—BAKELITE *Impact-Resistant* Phenolic is employed to reinforce the lower end of the lead-in socket; makes possible a molded thread with high mechanical strength for tube mounting.

3—BAKELITE *High Impact-Resistant* Phenolic assures maximum mechanical strength for small cross-sectioned supporting members for tube, port and cone.

4—BAKELITE *Transparent* Phenolic, for X-Ray port, withstands deterioration from beam passing through it; permits visual inspection of tube.

5—BAKELITE *Polystyrene* provides integral color for scale housing; is unmarred by moisture, chemicals, frequent handling. Unusual dimensional stability assures permanently secure assembly.

FIVE DIFFERENT PLASTICS *TO FIND A BULLET— IN A FIELD HOSPITAL*

This "Airflow" X-Ray Tubehead, heart of a mobile X-Ray Unit for the armed forces made by Picker X-Ray Corporation, New York, must be practically indestructible. It must function dependably despite the shocks of sea battle or land travel—despite Arctic cold or blistering desert heat. Actually, this complex, high-voltage electrical unit is a "miniature catalog" of BAKELITE Molding Plastics—proof again that there is a *right* plastic for every condition of service.

In this one unit, problems of impact and vibration, temperature extremes, high voltage, corrosion, transparency, and color-permanency are met and solved with BAKELITE plastic parts.

This plastics success resulted from the cooperation of a three-way team—the designer, the fabricator, and the plastic materials supplier. The same success can be achieved in your essential products, if you call upon Bakelite Field Engineers for help. To learn more about the characteristics of the BAKELITE Molding Plastics used here, write for Booklet 49-M.

BAKELITE CORPORATION, 30 E. 42 St., New York 17

Unit of Union Carbide and Carbon Corporation

UCC

Molding Plastics

Amersil*

(TRADE NAME REGISTERED)

ASSURES FINISHED PRODUCT PURITY

Because Amersil* (fused silica) is 99.8% pure silicon dioxide, it cannot contaminate acids or other chemicals handled in piping, cooling sections, absorbers, etc., made of it and absolute purity of the finished product is assured.

Amersil* is unaffected by any of the mineral acids—except hydroflouric (at all temperatures), and phosphoric above 270°F.—or by the halogens, with the exception of flourine. It withstands, permanently, temperatures up to 2100° F., with peaks up to 2700°F. permissible for short periods. Amersil's ability to withstand sudden and extreme thermal shocks without noticeable expansion or contraction is another of its many valuable characteristics.

For purer finished products, use Amersil* apparatus.

A new Amersil* Catalog is on the press. Write today—on your business letterhead, please—and reserve a copy.

*The registered trade name of the only American manufacturer of fused silica.

AMERSIL COMPANY Inc.

A subsidiary of Nichols Engineering & Research Corp.

60 WALL TOWER **NEW YORK 5, N. Y.**

For Your Castings

Z Metal

DUCTILITY
HARDNESS STRENGTH

- Maximum strength with minimum weight
- Accurate casts
- High machinability
- Low finishing costs
- Selective hardenability
- Maximum density with minimum porosity
- Corrosion resistant

WHAT IS Z-METAL?

Z-Metal is produced in the form of castings. Its properties reflect its microstructure. Metallographically, it consists of a matrix of alloyed ferrite, strengthened by iron carbide in the form of globules or "spheroids." The ductility of metal containing spheroidal carbides can be expected to be greater than that of metal containing the lamellar form of carbide.

The balance of the carbon present in the metal exists as fine particles of graphite or "temper carbon" which act as a lubricant, aiding machinability.

Z-Metal is not a cupola product, but is made in electric or air furnaces.

Z METALS

Investigate Z-Metal for your product. Write today for full information.

FERROUS METALS CORPORATION
444 Madison Avenue . . . . . New York, N. Y.

Briefs on Associations, Promotions and Education

The Institute of Scrap Iron and Steel, Inc. is going into public relations in a big way. A Public Relations committee has been appointed, composed of one member from each of the 22 chapters. Gerald M. Frank, vice president, M. B. Speer & Co., Pittsburgh, has been appointed chairman. One of the functions will be to watch for unfavorable publicity concerning scrap, as well as acting constructively by handing out to the press informative items.

A new dictionary, translating words used in the American automotive industry into the Chinese language, has been compiled by the Marmon-Herrington Co., Indianapolis. It consists of 252 pages, and lists nearly 10,000 terms and phrases. Up to time of going to press we have not learned whether "back-seat driver" is included.

"Due to the successful development of the steel cartridge case, there has been a saving of 185,000,000 lb. of brass strip to date," stated Major Walter C. Main, regional officer, Los Angeles Ordnance Dept. at a banquet of the National Association of Manufacturers in Los Angeles. For their development work on steel cartridges, citations were presented to Fred M. Arnold, Harry F. Ehrich and John A. Kingston, of the Norris Stamping & Mfg. Co. of Los Angeles; and to Harlan A. Messner, Ohio Crankshaft Co., Cleveland.

A national plastics exhibition will be held after the war, it was stated recently by George Scribner, president, Society of the Plastics Industry. In the exhibit will be many items now secret because of military expediency. The exposition will be comprehensive, involving plastics, machines that make them, and items in which plastic parts can be used.

The National Machine Tool Builders Assn. has presented a plaque to Mason Britton, vice president, McGraw-Hill Publishing Co., for his services to the nation in behalf of war production. "Under his direction the machine tool builders delivered the largest and most diversified aggregation of machine tools the world has ever known."

Rutgers University has created a research council to promote research in all departments of the university. Four projects in chemistry and three in engineering of immediate value to the war effort are now under way.

A United States section of the Pan American Institute of Mining Engineering & Geology has been formed. Members of any mineral industries society in the United States and Canada are eligible to join as charter members. The purpose is to foster good will and better understanding among mineral industries, engineers and technologists in the Western Hemisphere. The chairman is Edward Steidle, dean, Pennsylvania State College, State College, Pa.

The third National Chemical Exposition will be held at the Coliseum in Chicago Nov. 15 to 19, where will be revealed much that is planned for the post-war era. The exhibit area will occupy 56,000 sq. ft. as against 32,000 sq. ft. at the 1942 show.

CEREX

an injection-molded plastic serviceable in boiling water!

FROM MONSANTO research laboratories comes news of one of the most significant advances in the history of modern plastics . . . *a new plastic that can hold its shape and strength at temperatures above the boiling point of water . . . yet can be fabricated by the fastest, most economical molding methods.*

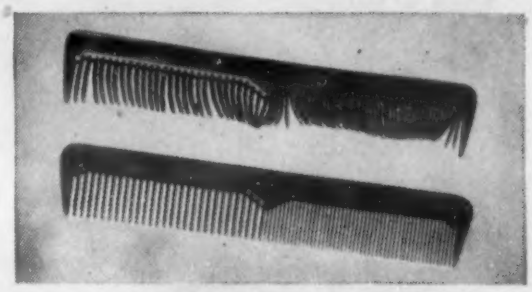
The new material, which opens up entirely new fields of usefulness to plastics, is Cerex.

Until development of Cerex, if you needed a plastic for service much above 200°F. where strength was important you were limited to materials that cannot be injection-molded, yet injection molding is the fastest, most fully automatic and generally the most economical of present molding methods. Now, with Cerex, you can produce articles that will serve without distortion at temperatures from 220° to 230°F. and you can mold them on standard injection machines in molds designed for other thermoplastics.

OTHER CEREX PROPERTIES

Other outstanding Cerex properties include excellent indentation hardness, with Rockwell hardness values well above any other moldable thermoplastic . . . good electrical properties . . . good strength properties, with tensile values in the same range as Lustron and somewhat higher flexural strength . . . good color possibilities since Cerex is naturally a clear, transparent amber and is compatible with a rainbow-wide range of dyes and pigments . . . *and high chemical resistance.*

Specifically, Cerex is not affected by alcohols, alkali or strong, non-oxidizing acids. In a series of prolonged tests, parts molded of Cerex withstood conditions that corroded enameled steel and attacked the surface of aluminum, while battery cases of Cerex have been subjected to boiling sulfuric acid solutions without effect.



Top comb was injection-molded from a standard polystyrene, then placed in boiling water for three minutes. Bottom comb, molded in same molds of Cerex, was left in boiling water thirty minutes.

HOW TO USE CEREX

Cerex compounds will eventually be priced within the present range of injection molding materials. While they undoubtedly will prove more desirable for some applications already filled by other plastics, their chief value will be in jobs for which no present-day plastic is fully qualified, physically or on a finished cost basis.

A few of those jobs are listed in the box to the right but many more possibilities will occur to engineers or designers.

HOW TO GET CEREX

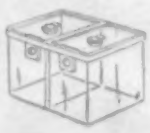
Cerex is still in pilot plant production and limited quantities will be available only for direct military uses until large-scale manufacturing facilities can be built.

Sample quantities, however, can now be supplied and arrangements made for experimental molding of test samples on critical war applications where no other available plastic is satisfactory.

If you have an application for Cerex that meets those qualifications, write or wire for full details: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Massachusetts.

Immediate Possibilities

Surgical and dental instruments that can be sterilized in boiling water.



Battery cases that would be unaffected even by boiling sulfuric acid solution.

Many electronic instrument parts now molded from mica-filled phenolics. Here it provides better electrical properties with high resistance to heat distortion.

Many essential industrial applications requiring high heat and chemical resistance.

Postwar Possibilities

Colorful, tough tableware, that could hold boiling water.

Bright, attractive kitchen utensils that could be safely washed in boiling water.

Plumbing hardware that could add a new note of color to bath and kitchen.

Special types of packages requiring high resistance to heat or chemicals.

For first time, small radio cabinets could be successfully injection molded.

The broad and versatile family of Monsanto Plastics includes: Lustron polystyrenes • Monsanto vinyl acetals • Nitron cellulose nitrates • Fibestos cellulose acetates • Resinox phenolic compounds • Resimene melamine compounds. Forms in which they are supplied include: Sheets • Rods • Tubes • Molding Compounds • Industrial Resins • Coating Compounds • Vuepak Rigid, Transparent Packaging Materials.

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METAL TREATING INSTITUTE

THE LAKESIDE STEEL IMPROVEMENT CO.
5418 Lakeside Avenue CLEVELAND, OHIO Phone Henderson 9100

House Organ Notes

Electromet Review, Electro Metallurgical Co., April, 1944.

"The tiny cobwebs of steel that help to control the balance wheel of a watch are among the most delicate springs industry has ever been called upon to produce. The steel must be drawn to about one-third the thickness of the average human hair. There are many other interesting types of springs —for instance, the stainless steel coils used for pressure-measuring instruments in processes involving handling of corrosive liquids or gases. Such a spring must have good resistance to rusting, and with high fatigue strength."

The Martin Star, Glenn L. Martin Co April, 1944.

"Glass fuel line sections, used in connection with a Lucite housed fuel selector valve, make it possible to trace the fuel flow through a PBM-3 Mariner fuel system at the Martin Service Training School. Transparent parts and sections may be used in airplanes of the future to provide a rapid means of locating trouble, thereby cutting down on service time and reducing costs."

D-H Alloy Craftsman, Driver-Harris Co., Vol. 4, No. 1.

"Should the Big Inch oil pipe line get clogged up with sludge, it must be cleaned out. The oil pressure itself does the work ordinarily, propelling a screw-type scraper in the pipe. But sometimes the scraper sticks. Then the Geiger-Mueller counter operates, depending on the radio-active metal in the scraper, which emits an impulse message. The G-M counter picks up these signals, the obstruction being cleared away at this point of greatest intensity. In the counter there are many specially designed resistors and controls, in which D-H alloy wires are prominent."

The Carbuilder, Pullman-Standard Car Mfg. Co., March, 1944.

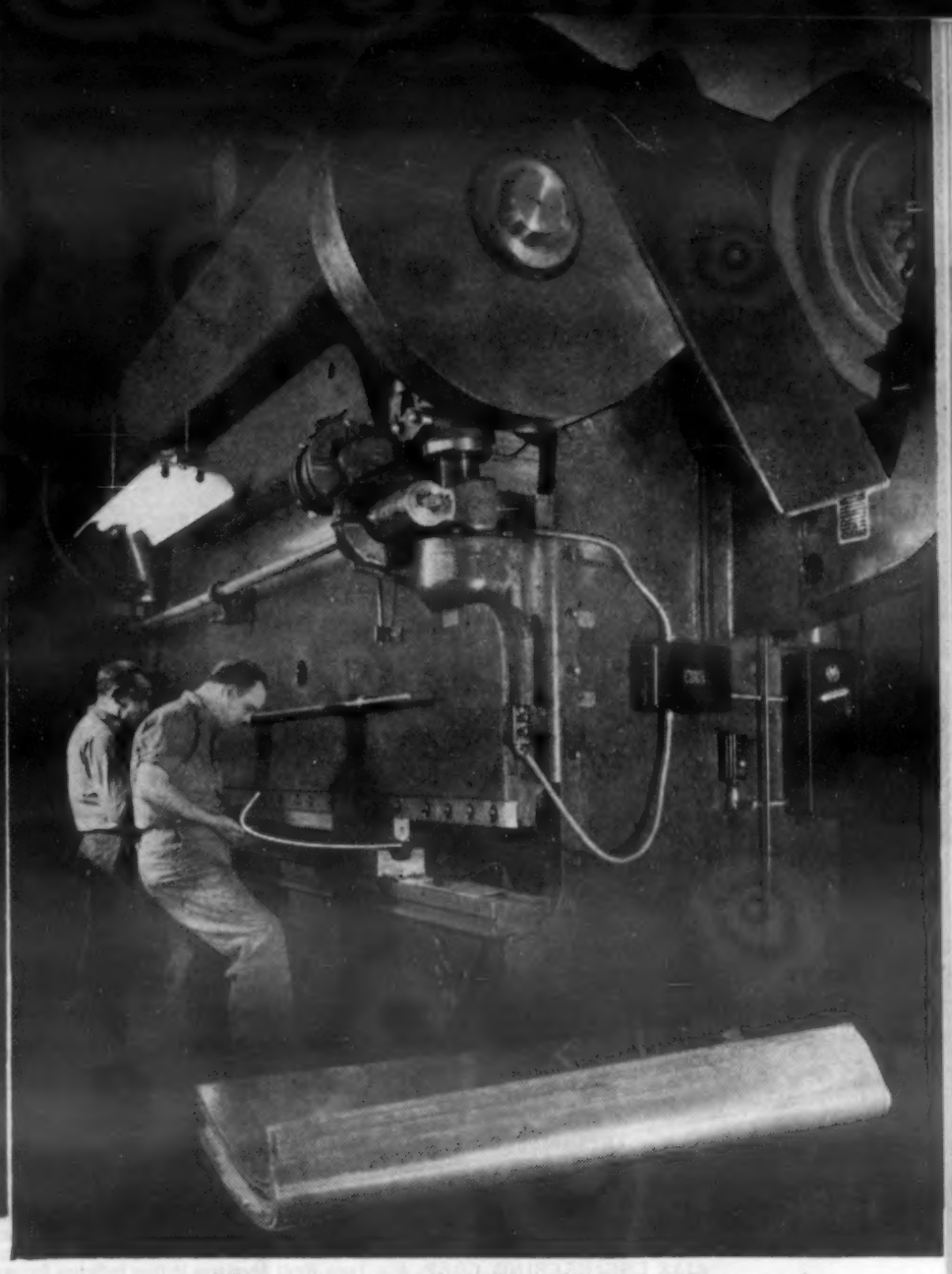
"Welding will be used extensively after the war to build lightweight box cars that will save up to 20% in weight, and increase payloads correspondingly. It will take many years to replace 1,700,000 over-age heavyweight freight cars. Welding is not modern, having been used in 800 B.C. to join iron and bronze. It joined metals, too, in knights' suits of armor."

Steel Stamina, Lindberg Steel Treating Co., May, 1944.

An article explains the theory of the use of sub-zero treatment of metals. Some steels retain austenite to a limited degree even when quenched. But aging often causes this austenite to break down into martensite, which is a bulkier material and hence causes the steel part to expand, which may be fatal in precision work. However, treatment as low as minus 130 F. accelerates aging and hurries this transformation of austenite to martensite so that the steel assumes its final size. Many alloyed steels will react to sub-zero temperatures, including SAE 52100, carburized nickel steels, air hardening varieties of high carbon chrome and carburized tungsten shock steels. The freezing is alternated with tempering at 300 to 400 F. Cold treatment prevents growth or change in cast iron or

R-301

STRONG, CORROSION-RESISTANT, WORKABLE



The superior workability of R-301 offers a major advantage in forming curved or flanged parts.

PLANE DESIGNERS wanted a higher strength aluminum alloy for increased performance. Aircraft shopmen wanted an aluminum alloy of good workability in order to reduce production time. Users of aircraft wanted an aluminum alloy with good corrosion resistance, to withstand *any* atmosphere and climate.

Reynolds' Metallurgists, reading these needs, created R-301.

R-301 is a high-strength aluminum alloy core, integrally bonded with a corrosion-resistant, medium-strength aluminum alloy cladding. The core and cladding alloys respond to the same heat treatment—resulting in a final product possessing high strength.

R-301 in the solution heat-treated temper is stable and more workable than any other high-strength aluminum alloy in the corresponding temper—thereby eliminating costly post-forming heat treatment and consequent distortion of aircraft parts.

R-301 is being produced in three tempers, suitable for a wide range of applications. Inquiries are invited. Reynolds Metals Co., Aluminum and Parts Division, Louisville, Kentucky.

Heavy, bending rolls, forming an armor hood for the pilot's compartment. R-301 can be cold-rolled to shape.

R-301 drills and routs to sha accurate contour. The ha surface cladding reduces the h ard of accidental scratching.

REYNOLDS METAL

REYNOLDS ALUMINUM

NOTE

•"Proper Melting Decreases Foundry Losses," contains interesting data. Also, the booklet, "Nonferrous Ingot Metals of Today." Write for both of these. They are free.

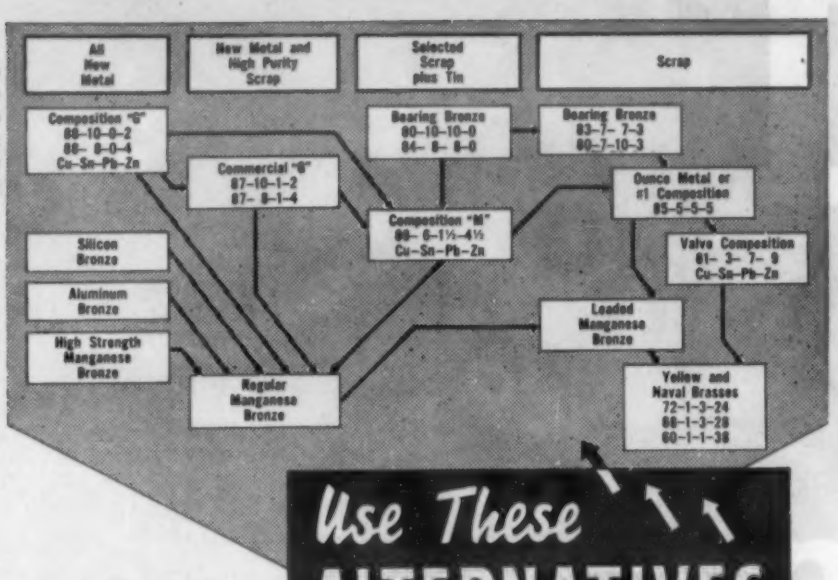
•

Send for booklet
"INGOT METALS OF TODAY"

•

16 STANDARD INGOT METALS BY AJAX

Ajax Tombasil
Ajax Plastic Bronze
Ajax Anti-Acid Bronze
Ajax Phosphor Bronze
Ajax Red Brass Ingots
Ajax Manganese Bronze
Ajax High-Tensile Manganese Bronze
Ajax Golden Glow Yellow Brass
Ajax-Hamilton Gear Bronze
Ajax Nickel-Copper 50-50%
Ajax Manganese Copper
Ajax Aluminum Alloys
Ajax Phosphor Copper
Ajax Silicon Copper
Ajax Nickel Alloys
Ajax Phosphor Tin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New Metal and High Purity Scrap
Selected Scrap plus Tin
Scrap
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Commercial "G" 87-10-1-2 87- 8-1-4
Bearing Bronze 80-10-10-0 84- 8- 8-0
Bearing Bronze 83-7- 7-3 80-7-10-3
Ounce Metal or #1 Composition 85-5-5-5
Composition "M" 88- 6-1½-4½ Cu-Sn-Pb-Zn
Valve Composition 81- 3- 7- 9 Cu-Sn-Pb-Zn
Silicon Bronze
Aluminum Bronze
High Strength Manganese Bronze
Leaded Manganese Bronze
Regular Manganese Bronze
Yellow and Naval Brasses 72-1-3-24 68-1-3-28 60-1-1-38

Use These ALTERNATIVES Wherever You Can

Notice how the arrows on the W.P.B. chart point to the *right*. . . . They show how alternative materials *currently available* can be utilized by foundrymen as now permitted by many designers. The purpose is to conserve primary metal at the mine through increased use of secondary ingots. Sometimes great ingenuity is called for, yet remember this:

The first program for scientific control of ingot metal was set up by Ajax 46 years ago. The result has been metal and practical technical follow-through in which Ajax increases your production by reducing rejects.

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ESTABLISHED 1880 PHILADELPHIA

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AJAX ENGINEERING CORP. Ajax-Tama-Wyatt Aluminum Melting Induction Furnaces

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ALUMINUM CASTINGS
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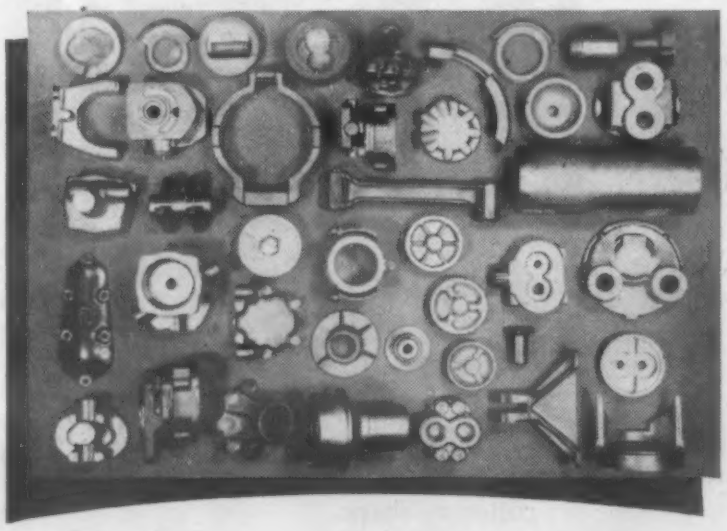
Heat Treated to all specifications
X-Ray and other inspection controls
Deliveries meet all schedules
Send in your inquires for war and civilian requirements.



DETROIT 8-254 Gen. Motors Bldg. CHICAGO 1424 A, Merchandise Mart BUFFALO 837 Potomac St.

NATIONAL
ALUMINUM MFG. CO., PEORIA, ILL.

cast aluminum. It is useful with high-speed steel to improve cutting qualities.

War Production Facts, Columbia Steel & Shafting Co., May, 1944.

Who has heard of a "goon gun?" We hadn't until we read this interesting, well illustrated sketch. In Italy a "goon gun" company engaged a battery of German 88-mm. guns and destroyed the enemy battery with only 12 rounds, though the 88 outweighs the 4.2 mortar ("goon gun") 30 times and has a range four times as great. David and Goliath stuff! "It has the homely appearance of a stove pipe supported by a T-square, yet it packs the punch of light artillery and can lob a score of 24-lb. projectiles 2½ miles in 60 sec.—and with deadly effect. The gun is rifled, and the shell has expanding rings, spinning like a rifle bullet. The fire is more accurate than that of common mortars. They have a blasting effect more severe than the shells from either a 105-mm. or 155-mm. The shell is made from cold-finished steel bars."

Vernon Alcoan. Vernon Works, Aluminum Co. of America. May 1, 1944.

"*The Defender,* which won the America's Cup Races in 1895, was aluminum from the water line up. Duck boats made of aluminum were common in those days, and even President Grover Cleveland used one on vacation. Under the 1922 Washington treaty, the Germans were not permitted to build anything larger than a 10,000-ton cruiser. But they used so much aluminum on the inside of the *Ersatz Preussen* that this vessel was the equivalent in fire power of a 30,000-ton cruiser."

Lead, Lead Industries Assn., May-June, 1944.

"The program sponsored by the plumbing trade to promote lead welding in place of wiped solder joints is well received by architects, engineers and city inspectors. The safety and security of the welded joint is accepted without question. Costs are favorable, too. With welding, no solder is needed except to tin the surface of brass fittings before welding to lead."

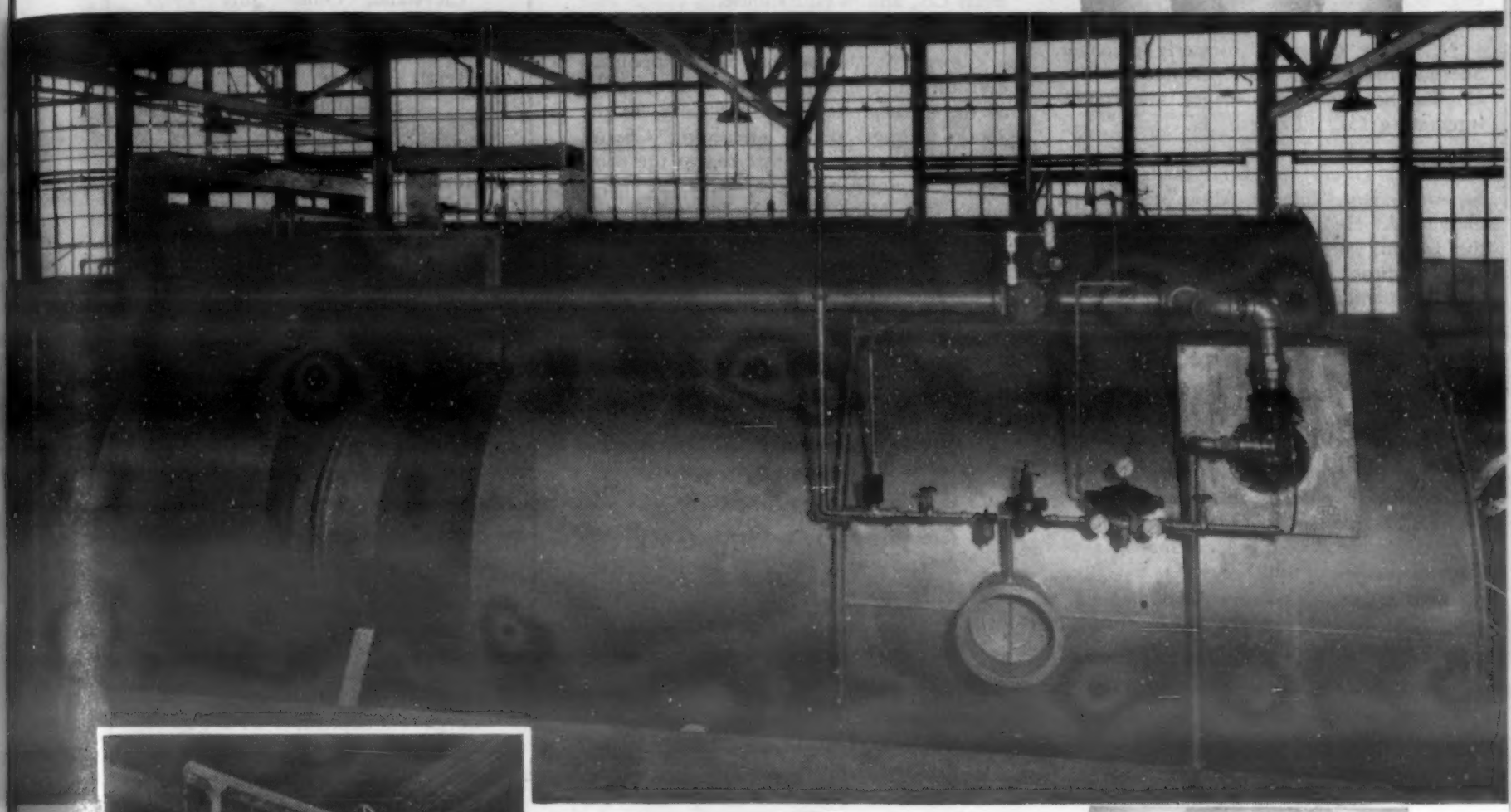
News of Engineers

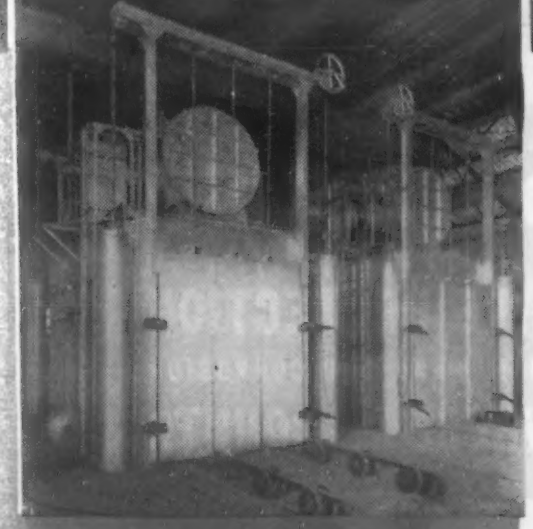
Dr. George H. Young has been appointed executive assistant at Mellon Institute of Industrial Research, University of Pittsburgh, and will be concerned with the management of research programs. He is an authority on corrosion and its prevention. Basic studies in anti-fouling and marine paints supervised by him during the past four years have attracted international recognition. He belongs to many technical societies, and has written many articles on corrosion.

Earl R. Sayre has been made application engineer in electrical, electronic and metallurgical products of P. R. Mallory & Co., Inc., Indianapolis. He was formerly with Arrow-Hart and Hegeman Electric Co.

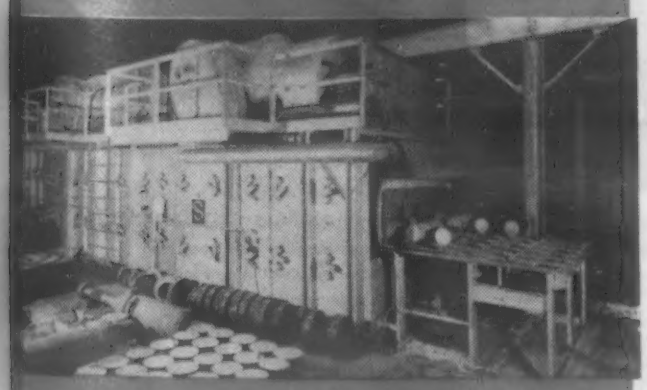
William F. Lamoreaux has been made research metallurgist, Cooper-Bessemer Corp., having for the past three years served as director of research for the Meehanite Metal

CONVECTION FURNACES *by* SALEM





Salem Dolly Car Type Furnaces for heating plates and sheets, weldments and jigs



Salem Chain Conveyor Type Furnace for heating round, aluminum billets

War Production Has Proved Convection Heating Most Efficient, Low-Cost Method . . .

Convection heating for low-temperature work (300° F.-1350° F.) costs less, delivers heat to all parts of charge at same time, acts faster than direct-firing, and is much cleaner than all other gas or oil-fired types.

Heating engineers predict that convection heating, as a result of its proved efficiency and economy, will be widely adapted to peacetime production when the goal of every manufacturer will be quality at lowest cost.

Salem Engineering Company builds convection furnaces in a complete range of sizes and styles . . . for heat treating, stress-relieving, aging . . . for ferrous or non-ferrous materials in billets, sheets, plates, castings . . . weldments, jigs, or fixtures.

In organizing your planning, talk over your heat treating ideas with Salem engineers. They can point out many time and cost-saving steps.

SALEM ENGINEERING COMPANY

SALEM ENGINEERING CO. · SALEM, OHIO

Corp. He will closely integrate the company's engineering, metallurgical and foundry efforts, and will explore the application of high duty iron castings to mining and heavy chemical fields. For five years he was a consulting chemical and metallurgical engineer.

H. Roger Coleman, formerly manager, Special Products Sales Div., General Aniline Co., has become sales manager, Metals Disintegrating Co., Elizabeth, N. J.

Jack E. Gould has been made general superintendent, Tubular Alloy Steel Corp., Gary, Ind. He began with U. S. Steel at the Lorain works, National Tube Co., in 1930 as junior metallurgist, promoted later to superintendent of metallurgy. His last position was assistant vice president in charge of operations in the Pittsburgh office, National Tube Co.

Edward L. Miller has been made manager of engineering, in charge of design engineering and research departments, American Machine & Metals, Inc., East Moline, Ill. He succeeds *C. W. Anderson,* promoted to vice president and general manager of the company's new subsidiary, U. S. Gauge Co., Sellersville, Pa.

M. D. Bensley has been appointed general manager of the three plants of H. K. Porter Co., Inc., Pittsburgh. In 1917 he purchased and operated the Frontier Bronze Corp., Niagara Falls, N. Y., and for several years was with Shenango Penn Mold Co.

Clinton E. Swift has joined Eutectic Welding Alloys Co. as assistant manager of the engineering and research department. Previously, he was manager of the welding division of Ampco Metal, Inc. He has also been with C. F. Braun Co., American Brass Co., and Westinghouse.

George S. Mican has been appointed division superintendent of rolling mills of the Carnegie-Illinois Steel Corp. in the South Chicago plant, succeeding *Charles C. Hill, Jr.,* who is transferred to the company's engineering department in Pittsburgh. Mr. Mican has enjoyed several years experience with rolling mills. Mr. Hill began steel work in 1919 in an open hearth department.

Roy L. Salter is the new works manager of the Southern Wheel Div., American Brake Shoe Co. For five years he was with the Association of Manufacturers of Chilled Car Wheels. He first joined his present company in 1924.

T. R. Porter has joined the staff of North American Philips Co., Inc. as technical-commercial man on high frequency heating. He has been with Westinghouse for the past eight years, where he did development in the electronic field.

Paul H. Mielke has been made sales and service representative of the Shenango-Penn Mold Co. for its Pittsburgh territory.

Meetings and Expositions

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual convention. Cleveland, Ohio. July 19-21, 1944.

INSTITUTE OF AERONAUTICAL SCIENCES, summer meeting. Los Angeles, Calif. July 27-28, 1944.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, Pacific Coast technical meeting. Los Angeles, Calif. August 29-September 1, 1944.

AMERICAN CHEMICAL SOCIETY, semi-annual meeting. New York, N. Y. September 11-15, 1944.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, annual meeting. Cleveland, Ohio. September 11-16, 1944.

SOCIETY OF AUTOMOTIVE ENGINEERS, national tractor meeting. Milwaukee, Wis. September 13-15, 1944.

ASSOCIATION OF IRON & STEEL ENGINEERS, annual meeting. Pittsburgh, Pa. September 25-27, 1944.

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ACCURATE and light weight. Only 8 lbs. 4 oz. Measures just 8¼"x6¼"x3". Capacities from 0-500 lbs. up to 0-10,000 lbs. Hundreds of uses in lab. or shop. Priced low. Delivery from stock.

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GIVE PROTECTION FROM WEAR AND CORROSION WHERE IT COUNTS

WITHOUT THIS PROTECTION . . .

The photographs reproduced above and to the left were taken after accelerated tests made under impartial supervision. The PERMOPIVOT (above) shows no signs of wear while the ordinary steel pivot (left) shows serious damage.

Every PERMOPIVOT* is tipped with Permometal* . . . a special precious-metals alloy developed and manufactured in Permo's own metallurgical laboratories. Permometal's extremely low coefficient of friction, its satin-smooth polish, and its resistance to corrosion and abrasion make it ideal for tipping pivots. PERMOPIVOTS eliminate the need of oil . . . keep precision instruments accurate longer . . . even under the most gruelling punishment.

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King, Andrew 258
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By Edwin F. Cone

Plenty of Magnesium

Production of primary magnesium metal during the first quarter of 1944 averaged over 41,000,000 lb. per month, according to the Aluminum and Magnesium Div. of the WPB. This will probably remain a peak output for the duration since some curtailment took effect late in March. Recovery of secondary metal reached a new high of 3,500,000 lb. in March, and in this case also a new high for the quarter was attained at 8,300,000 lb.

More Welding Wire

For each ton of finished steel last year over 17 lb. of welding wire were made compared with almost 13 lb. in 1942 and over 7 lb. in 1941, according to a recently released statement of the American Iron and Steel institute. The 1943 output rose about 42% above that for 1942 for a record total of 1,166,400,000 lb. or 583,200 net tons.

Solders after the War

From a report of the War Metallurgy Committee we learn that there is little likelihood of a return to the use of the pre-war tin-lead solder in the post-war era. The behavior of a solder joint of about 95% Pb, 2% Ag and 3% Sn in side seams of sanitary cans is reported as so satisfactory that it is unlikely that a return would be made to the 70% Pb-30% Sn solder, even if tin were in plentiful supply. The lead-silver solder thus bids fair to be not a "substitute" to be abandoned after the emergency, but a replacement for much lead-tin solder.

Electricity in Electrochemistry

In 1943 the electrochemical industry, which is based on the use of electric power, consumed more than 20% of all the electric energy produced in the United States and Canada. In quantity this amounted to about 60,000,000,000 kw.-hr.—a 5-fold increase over the consumption for 1936 and 12-fold over that of 1926. Even more striking perhaps is the fact that this quantity, 60 billion kw.-hr., is three times the total power generated in the United States in 1913. This enormous energy consumption is a spectacular measure of electrochemistry's war effort. These statements were made by R. M. Burns in his presidential address before The Electrochemical Society in April.

Alloy Steel Output Declining

Production of alloy steels is declining this year as compared with 1943. For the first 5 months official data show that the total alloy steel output this year had been 4,596,867 net tons or 25% less than the 6,133,395 tons made to June 1, 1943. Of this year's total, open-hearth furnaces made 2,987,893 tons or 64.9% with 1,608,964 tons made in electrical furnaces.

Steel for Ships

In the first quarter of this year shipbuilders continue to rank first in the consumption of finished steel as they did in the last year or two. According to a recent statement of the American Iron and Steel Institute, they received about 3,221,000 tons or 20.7% of the total in the first quarter of this year.

Mounting Steel Company Payrolls

The payrolls of American steel companies in 1943 stood at the record level of $2,653,505,000 which includes the payrolls of a number of steel company subsidiaries that do not produce steel. Last year's payroll was more than 20% higher than in 1942 and was largely responsible for the reduction in earnings last year. In 1942 they amounted to $2,176,051,000.

Ferromanganese and Spiegel

Production of ferromanganese and spiegeleisen by American furnaces this year is at a fairly high rate. To June 1, this year, the average monthly output had been 57,560 net tons. This compares with 56,900 tons per month for 1943.

Steel Payrolls Expanding

A new high record in payrolls for the steel industry was registered in March at $145,225,000 says the American Iron and Steel Institute. The previous peak was $114,937,000 in October, 1943. The March 1943 total was $136,813,000. At the same time the average number of employees has declined.